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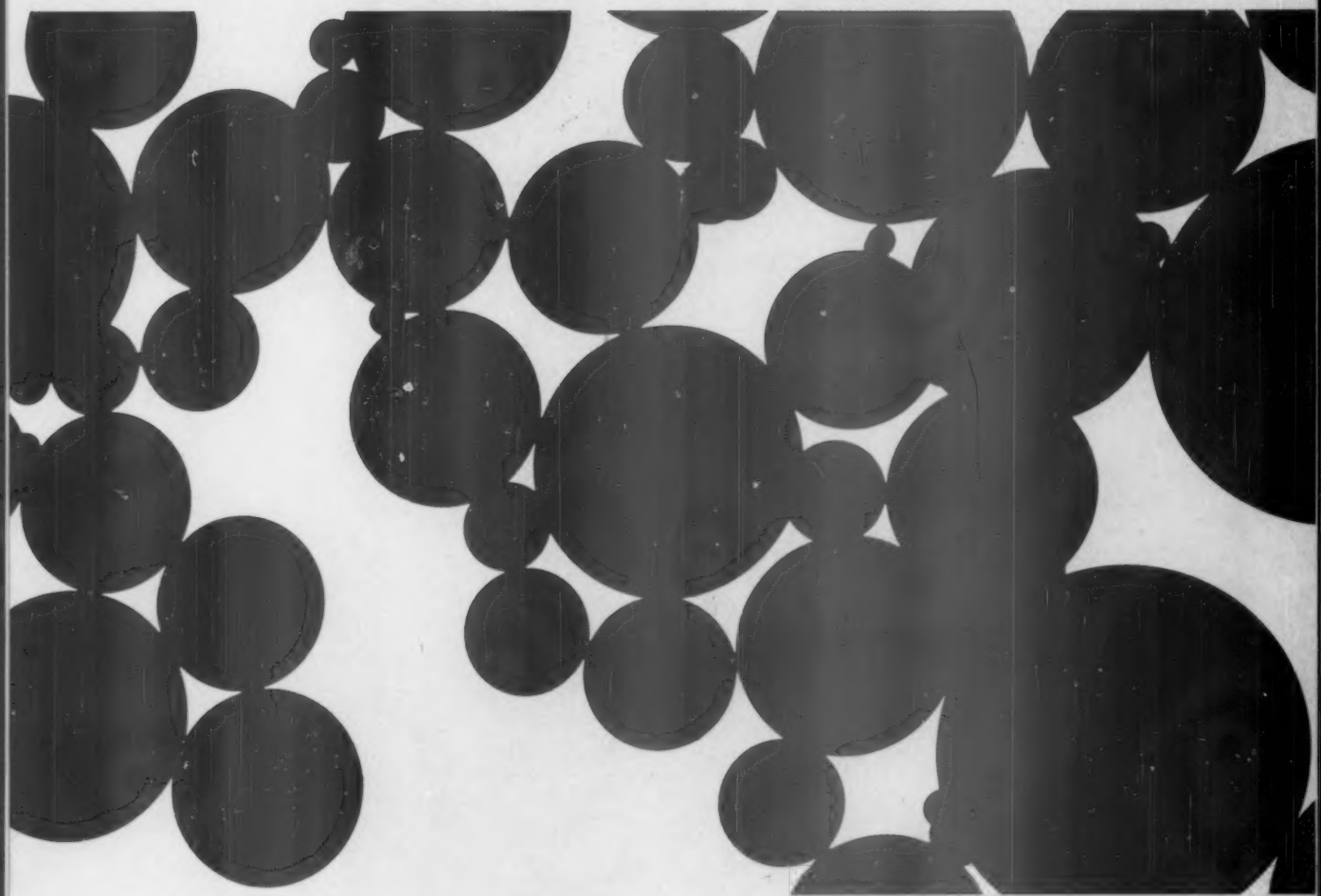
food technology



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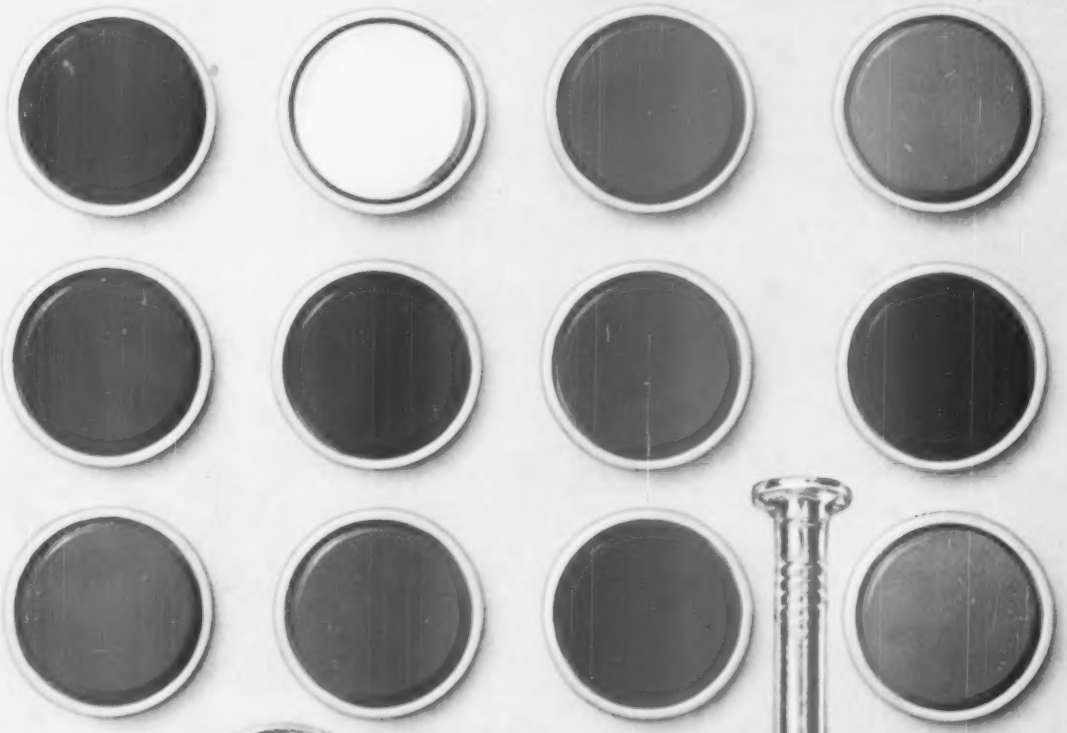

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IN THIS ISSUE—

TECHNICAL ARTICLES IN BRIEF

Physics — *Convection in a non-homogeneous fluid*

Convection in syrup-packed products. R. C. Nicholas, I. J. Pflug, and T. R. Mulvaney.

Most analytical treatments of convection heating are restricted to the case of a homogeneous fluid in which the density differences that cause convection are the result of temperature differences only. However, if the fluid is not homogeneous, as is the case when the syrup concentration is not uniform throughout the container, then density differences will be a function of both syrup concentration and temperature. Because the density is a function of these two variables, there can be combinations of syrup concentration and temperature that will prevent convection currents. It is the purpose of this paper to show what combinations of syrup (sucrose) concentration and temperature will prevent convection. A method of calculating a criterion of no convection in syrup-packed products is presented. Evidence to suggest how this criterion is related to the difficulty of heating syrup-packed products in which product-induced stratification has occurred is provided. (See page 205).

Physics — *Processes resulting in stratification of product*

Product-induced stratification of covering syrups. T. R. Mulvaney, R. C. Nicholas, and I. J. Pflug.

Product-induced stratification is the name given the concentration gradient of soluble solids which results when foods of high water and low solids content are placed in sugar syrup. When the syrup is first poured over the product, the concentration of solids in the syrup is uniform throughout the jar; when the product is marketed some months later, the soluble solids concentration of the syrup,

May Cover. In addition to recognized virtues of corn oil, how many of us have given a thought to the aesthetic value of this versatile product? Our cover is a microphotograph of a corn oil emulsion fixed with osmic acid, taken with an RCA EMU-3 Electron Microscope at a magnification of 8000 X. Submitted by IFT Member Jack Pangborn, Electron Microscope Lab., University of California, Davis.

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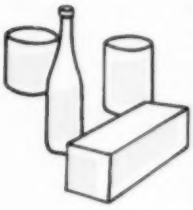
The Story of Nature's Yellow

WHY IS COLOR SO IMPORTANT?

Colors call to your appetite. You pick the big, red, beautiful apple and every bite seems to taste better because it's so nicely red. The good, thick steak looks crusty brown, and the center's a wonderful pink.



Some foods are naturally attractive. Some must be made so. Butter and margarine must be a good yellow for widest appeal. Gelatin desserts, children's lollipops and hard candy, soft drinks, ice cream, and many other foods must be colored for consumer acceptance. Man so often must help nature out!

Making foods look better, making them taste better, making them nutritionally more valuable are practices everyone accepts and expects. Food processors can now add pure beta carotene Roche* to give natural yellow color, plus vitamin A value, to their good foods.

WORDS AND MEANINGS

Carotene (sometimes spelled *carotin*) is the root word. It designates a color compound which occurs naturally in some vegetables and fruit.

Carotenoid describes a family of color compounds, found widely distributed in nature, which gives many flowers, fruits, leaves, and vegetables their characteristic color. The ending "oid" is the way chemists say: "like carotene." All carotenoids are similar, chemically, to beta carotene which is the most important and widely distributed member of the carotenoid family.

Beta Carotene. The Greek-letter prefix is used to distinguish this compound from *alpha* and *gamma* carotene — compounds which have somewhat similar chemical structure but are not nearly so important in human nutrition.

Provitamins describe substances which are changed in the body into vitamins. Beta carotene is a provitamin; the body converts it into vitamin A which we all need for good health.

*Roche — Reg. U. S. Pat. Off.

CAROTENE IS NO STRANGER

Carotene is as common as carrots, or sweet potatoes, or green leaves, or the natural yellow of butter. Carotene is the pigment which makes carrots, *carrot-colored*. Carotene and other carotenoids, with chlorophyll, are present in the green leaves of plants. Vivid proof of this is seen when tree leaves turn yellow in the fall.

A LARGE FAMILY WITH MANY RELATIONS

Nature has many pigments: the delicious red of a ripe strawberry, the many shades of green in leaves, the blue of cornflowers, the lavender of lilacs, the differing browns of bark, the bright yellow of daffodils, the darker yellow of plump pumpkins.

All of the carotenoid colors have somewhat the same chemical structure. As their chemistry varies, so do their properties. Different carotenoids may exist side by side, as in some tomato species which contain beta carotene and lycopene, the so-called tomato red.

No one knows exactly how many carotenoids there are in nature. Some authorities believe there may be as many as 200.

Of all the carotenoids now known, beta carotene is the most useful for human beings, because of its value as a provitamin A. Not all carotenoids are provitamins. Alpha carotene, gamma carotene, cryptoxanthin (found in yellow corn) and some less well-known compounds have this property to only a limited extent.

BETA CAROTENE DESCRIBED

In pure form, beta carotene is deep violet-red in color; in dilutions its color is yellow. The crystals are flat platelets in form. The pure product has very powerful coloring properties. For example, three grams of the pure crystals, enough to cover an American quarter-dollar, will color a half-ton of margarine to the accepted yellow color.

Beta carotene is soluble in various oils, vegetable oils being preferred for food use. It is insoluble in water.

In the solutions customarily used in food processing, beta carotene Roche has practically no odor or taste, nor does it impart any odor or taste to the foods with which it is mixed.

Only a minute amount of crystalline beta carotene is needed for coloring. To simplify measurement for food processors, Roche has made suspensions of its finely ground crystals in vegetable oil. These are standardized, so that products with uniform color will result when they are used.

BETA CAROTENE IS A SAFE COLOR

Beta carotene is one of nature's own coloring agents. It has been consumed in food for thousands upon thousands of years. Even with this evidence of safety in usage, Hoffmann-La Roche did not market its man-made duplicate of nature's product until careful studies showed that this substance produced no undesirable effects in test animals. These and other tests indicate that beta carotene produced by the Roche process is safe and desirable for use in foods.

...BETA CAROTENE

by SCIENCE WRITER

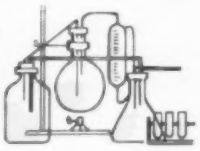
A CAPSULE HISTORY

In 1831, Wackenroder, curious to know what caused the characteristic color of carrots, isolated carotene from the roots of that vegetable. Based on his observation, Willstätter established carotene's empirical formula in 1906.

In 1919 the vitamin A activity of the carotenoids was discovered by Steenbock.

Between 1928 and 1930, Zechmeister, Karrer, and Kuhn established the constitution of carotene and assigned its structural formula.

In 1953, the successful synthesis of beta carotene was made by Hoffmann-La Roche whose chemists *duplicated* nature's own color in the laboratory. Commercial production followed within a year.



Carotene has been used by food processors in the United States for many years. Natural extracts have been made from carrots, palm oil, alfalfa, and other sources for more than 25 years. None of these natural extracts, however, has the purity of the man-made substance produced by Hoffmann-La Roche.

FOODS USING BETA CAROTENE

Beta carotene Roche is now used every day as a safe, natural, yellow coloring agent for such foods as:

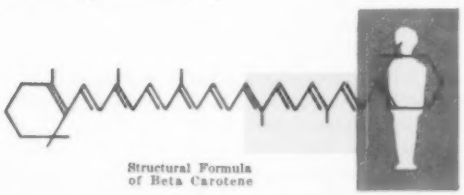
Margarine	Salad and Cooking Oils
Shortening	Confections
Lard	Yellow Baked Products
Butter	Beverages
Cheese	Ice Cream Products

It is capable of being used in almost any processed food. Developments at Hoffmann-La Roche have made it available for use in fatty foods and in special water-dispersible form for other foods.

An acceptable coloring in the U.S.A. since 1947, beta carotene has also received official sanction in Austria, Australia, Denmark, Finland, Brazil, Germany, Great Britain, The Netherlands, Norway, and Switzerland.

NUTRITIONAL VALUE

Beta carotene is a provitamin; it is converted into vitamin A in the healthy human body.



Structural Formula of Beta Carotene

Its biological activity is measured in units of vitamin A activity. One gram of beta carotene equals 1,666,700 U.S.P. units of vitamin A, while a gram of vitamin A (alcohol) equals 3,333,300 U.S.P. units. One U.S.P. unit is equal to 0.344 micrograms of vitamin A acetate.

We need vitamin A to guard the health of our eyes and our skin, membranes, and other specialized tissues. It helps build our resistance to infections. Vitamin A is needed for normal growth from infancy to maturity.

Beta carotene Roche is more than just another efficient food color. As it is so intimately associated with vitamin A, it comes close to being an essential substance in itself.

Of the six provitamins A known to exist in nature, beta carotene is the most widely distributed, the most potent in vitamin A activity, and the most readily available.

The Food and Nutrition Board of the National Research Council recommends that healthy adults in the U.S.A. receive 5,000 U.S.P. units of vitamin A daily in their diets. The requirements for pregnancy, for infants and children, vary above and below this amount.

OPENING ANOTHER DOOR TO THE FUTURE

The successful synthesis of vitamin A by Roche scientists led to the synthesis of beta carotene. The latter synthesis will no doubt lead to the manufacture of other carotenoids. Right now, work is being done on "duplicating" lycopene, the dominant red of tomatoes, and on cryptoxanthin, a yellow color found in corn. The development of pure beta carotene Roche is really only a beginning, not an ending.

SOME NEW WORDS ON FOOD PACKAGES

The identifying words: "artificially colored with beta carotene" on the labels of margarine, yellow shortening, yellow cake mixes, and various other food products signify that the manufacturer has used a safe yellow color which was conceived by nature itself for coloring foods and adding to their nutritional value.

HELP FOR YOU

Reprints of this article are available in reasonable quantities as a teaching aid or for public education. For food processors the Roche technical brochure is available. Those interested specifically in the scientific study of beta carotene will find published material from Roche most helpful. In making your request, please specify the type of information you want. There is no charge, of course.

Please address all requests to Dept. of Education, Fine Chemicals Division, Hoffmann-La Roche Inc., Nutley 10, N. J. In Canada: Hoffmann-La Roche Limited, 1956 Bourdon Street, St. Laurent, Montreal 9, P. Q.

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although lower than it was initially, is again uniform. However, soon after the syrup is added to the product, a non-uniform gradient of soluble solids concentration is created because water leaving the product rises to the top of the jar, instead of diluting the surrounding syrup. Moreover, this non-uniform gradient is large enough to inhibit convection, and continues to increase throughout the heating period. The authors are primarily concerned with the dynamic processes which result in product-induced stratification in sweet fresh cucumber spears. In one test with a heat processed sweet, fresh cucumber spear product, 2 minutes after adding the syrup, a difference of over 9% was found between top and bottom soluble solids concentrations in the syrup. This top-bottom difference in soluble solids concentrations continued to increase up to about one day after adding syrup. The soluble solids concentrations in the product lagged behind the concentrations in the syrup; appreciable differences persisted up to 4 days after adding syrup; equalization of soluble solids between the product and its surrounding syrup was reached at about 8 days after adding the syrup, but final equalization throughout the jar was reached only after several months. Acetic acid concentrations and pH were also found to be different between top and bottom of the jars. There was no salt in the covering liquor used in these tests, but the authors think that salt would also stratify. It should be emphasized that stratification takes place during heat processing. Comparisons between heated and unheated jars of cucumber spears show that although both top and bottom soluble solids concentrations in heated jars are lower than those in unheated jars at corresponding times up to an hour after adding the syrup, the differences, and, therefore, the average gradients are about the same. Stratification during the heating period should retard convection. Agitation of the jars is discussed as a means of eliminating stratification during the heating period and thereby improving heat transfer, but agitation is not recommended without qualification. Arguments are presented to suggest that there are ways to minimize the time required for final equalization of soluble solids between syrup and product throughout the jar. The present study has shown that during heat processing of syrup-packed products the water leaving the product selectively dilutes the syrup (sugar and acid). Given this fact, the question of heat destruction of microorganisms in syrup packs should be re-examined to take account of the constantly changing sugar and acid conditions to which these microorganisms are exposed during processing. In some regions of the jar the sugar and acid conditions may be significantly lower than were anticipated when the heat process was designed. (See page 207).

Physics *Convection heating studies*

Convection heating studies of water-syrup layered systems. R. C. Nicholas, I. J. Pflug, and T. R. Mulvaney.

Two model systems with built-in stratification that restricted convection to selected regions of a jar were examined to determine the effect of stratification on the heating characteristics throughout the jar. Heating rates, f_h, and lag factors, j, are presented for both model systems at 4 points in the 16-oz jars for each of five different layered arrangements. When there were two liquids of different density in a jar the heating rates, f_h, were affected depending on the particular arrangement, the position in the jar, and whether plastic spears were used. For example, in the layered system with plastic spears in which the layered arrangement was half-water and half-syrup, there existed large temperature differences in the syrup section that would normally lead to convection. Ten minutes after this jar had been in the 180° F water bath, a difference in temperature of 35° F existed between points only 2.5 cm apart; the colder point was above the warmer point, and this temperature inversion persisted throughout the heating period. In general, the slowest heating points were found in the regions just under the boundary between water and syrup. Heating rates were more affected than lag factors. In both systems studied (with and without plastic spears) the all-water pack was the fastest heating (over-all jar average), but the all-syrup pack heated nearly as fast. The data suggest that the syrup alone is not responsible for the slow heating regions observed in some of the arrangements. The resemblance of these model systems to food systems is remote, to be sure, for obvious reasons. No liquid exchange takes place between "product" and covering liquor. The sucrose concentration gradient remains essentially constant throughout the heating period. These concentration gradients are present at the beginning of heating and are larger than those found in food systems. Nevertheless, the authors believe that these results are suggestive of the changes in heating characteristics that are brought about by product-induced density gradients, and the density gradients produced by any external cause, such as adding dry sugar. (See page 212).

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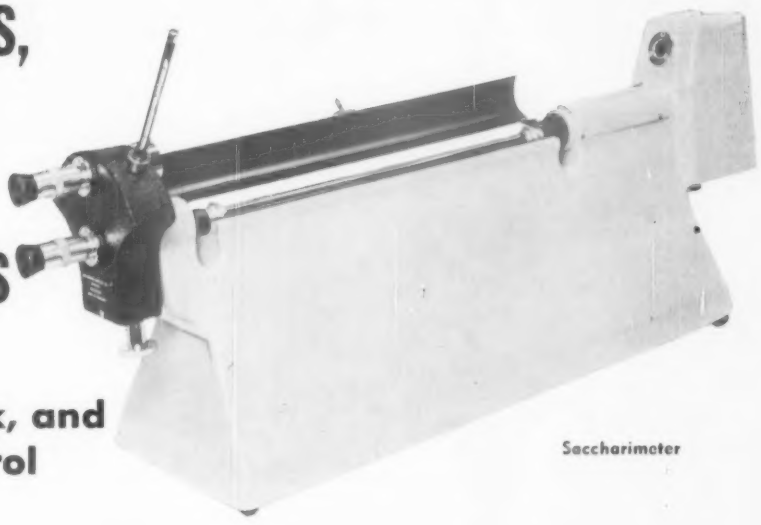

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Food engineering *Measuring beef tenderness*

A food grinder-recording ammeter method for measuring beef tenderness. J. A. Emerson and A. Z. Palmer.

Two trials were conducted comparing a motorized food grinder-recording ammeter apparatus and the Warner-Bratzler shear apparatus to a taste panel of 4 judges as methods of evaluating tenderness in beef. Tenderness values of the food grinder method were expressed as joules of energy consumed per gram of sample (E/g). In Trial 1, the taste panel was found to be the most repeatable method, closely followed by the Warner-Bratzler shear and the food grinder using broiled samples. Testing raw samples, the food grinder was found to be the least repeatable method. Correlation coefficients showed a higher relationship between the taste panel and the Warner-Bratzler shear (−.73, −.53, −.56, −.62) than between taste panel and the food grinder methods (−.60, −.27, −.61, −.33). The food grinder method using broiled samples was more highly correlated to taste panel than was the food grinder using raw samples (−.48, −.26, −.39, −.24). In Trial 2, the food grinder using cooked samples of roasts and the food grinder using raw samples were both found to be rather high in repeatability. A higher correlation was found between taste panel and Warner-Bratzler shear (−.79) than between taste panel and food grinder (−.47) using cooked samples. The food grinder method using cooked samples compared more favorably to taste panel (−.47) than did the food grinder using raw samples (−.20, −.41). Under the conditions of this investigation, the Warner-Bratzler shear apparatus appears to be a more precise measurement of tenderness than the food grinder. (See page 214).

Antibiotics *Penetration into fish*

Penetration of tetracycline antibiotics into tuna, sole, and rockfish flesh and their stability during steaming and retorting. Peter A. Lerke and Lionel Farber.

The penetration into whole tuna and into fillets of sole and rockfish of chlortetracycline and of oxytetracycline into tuna was studied. No effect of NaCl on the penetration into tuna flesh of the antibiotics was found. The skin and outer layer of flesh acted as a quite efficient barrier to the penetration of the antibiotics into the deeper layers of the meat. This decreased penetration facilitated subsequent destruction of active antibiotic during the steaming operation which is part of the tuna canning procedure. No active antibiotic residues were found in any cans of tuna packed from antibiotic-treated fish. The uptake of chlortetracyline by sole fillets was quite rapid during the first 5 minutes of immersion, after which the rate tended to decrease up to an hour. The chlortetracycline in sole and rockfish fillets was quite stable up to 7 to 9 days storage at 41° F (5° C); average losses during the storage periods were 16.8% and 16.5% respectively. Heat treatments of steaming, baking and frying, simulative of home preparative procedures, were found to markedly inactivate the active CTC originally present in the fillets of sole and rockfish. The actual amounts of antibiotic remaining after the various heat treatments were very small and could be considered as rela-

tively insignificant, particularly in view of the statement by the Food and Drug Administration on April 16, 1959, relative to the safety of any antibiotic residues in cooked seafood. (See page 217).

Packaging *Redness loss in prepackaged beef*

Pattern of redness loss and regeneration in prepackaged beef. Robert W. Dean and C. Olin Ball.

The pattern of color change in storage of fresh beef samples from a given source is essentially the same for any given set of packaging conditions. Sometimes, the pattern is practically identical in beef cuts coming from different animals. There is considerable evidence, however, that the inherent characteristics which differ in meat from different animals may be responsible for substantial differences in color history during storage. In containers that hold vacuum, the red color which appears in meat a few days after packaging is a durable color. The color of meat in vacuum tight containers is relatively stable for a period longer than the shelf life of the product. If mechanical problems in film packaging can be solved, it is apparent that meat can be vacuum packaged centrally and the meat industry will have entered a new era in distribution practice. (See page 222).

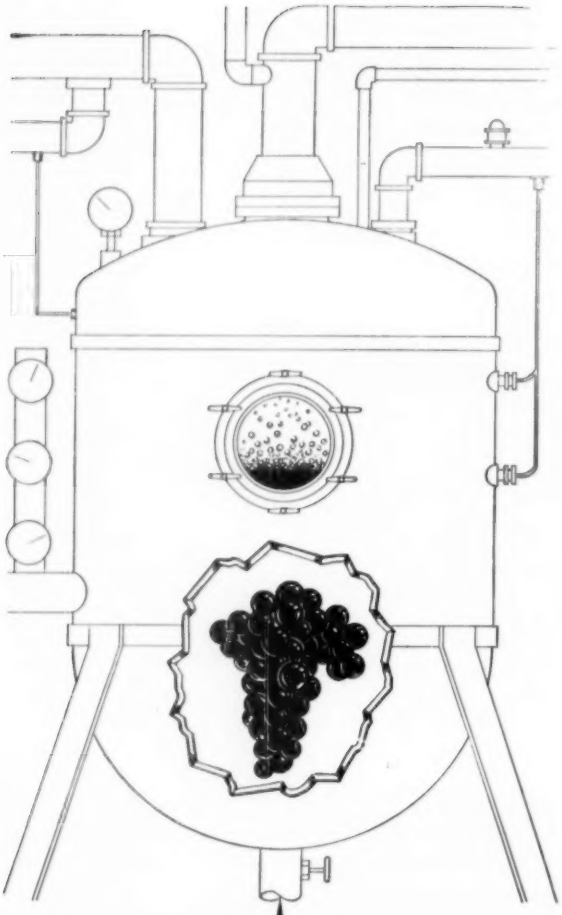
Effect of variables *Precooked frozen sweet potatoes*

Effect of variety, curing and processing on carbohydrate content of precooked frozen sweet potatoes. M. W. Hoover and D. T. Pope.

An investigation was made to study the effects of variety, syrup concentrations and curing treatments on the carbohydrate content of sliced precooked, frozen sweet potatoes. The sweet potato varieties included Porto Rico, Goldrush, NC 171, Redgold and Georgia Red. The roots were sliced and cooked in syrup solutions containing 0, 30, 45 and 65% sucrose, by weight. Cured and uncured sweet potatoes were processed. The per cent total solids, total sugar and sucrose in the samples increased rapidly as the syrup concentration advanced from 0 to 60% sucrose. The average per cent total sugar increased from approximately 9% for samples cooked in water for 10 minutes to 21% for those cooked in a 60% sucrose solution. The apparent increase in per cent total sugar was accounted for almost entirely by an uptake of sucrose from the cooking media. On a percentage basis, there was a small increase in maltose and a decrease in reducing sugar as the syrup concentration advanced. There was little apparent change in per cent alcohol insoluble solids and starch that could be attributed to syrup concentration. Wide variations in certain carbohydrate components existed among varieties. However, each variety responded similarly during the cooking process. Little variation in carbohydrates was found in frozen sweet potatoes that could be attributed to curing treatments. Weight losses occurred during the cooking process. In some instances it amounted to more than 7%. The higher the syrup concentration the greater the weight loss. Weight losses varied widely among varieties, with Porto Rico having the least and Goldrush the highest. (See page 227).

Flavor evaluation *Turkey broth*

Flavor differences in broths prepared from hormonized and non-hormonized turkeys. Grace Bennett.



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Turkey broth was prepared from hormonized, hormonized with added fat, and control turkeys and presented to 8 judges as triangle comparisons. Judges were unable to distinguish between 3% fat and 4% fat homogenized into the broth in which it was cooked or between 3% levels of the fat from different broths homogenized into control broth. Judges were able to distinguish between 3% levels of fat homogenized into the broth in which it was cooked and between samples of the broth alone. These results indicate that the difference between broth preparations of control and hormonized turkeys is not caused by texture or flavor differences in the fat but by differences in the broth itself. Judges rated the amount of turkey flavor of the broths in the following order: hormonized having the least amount of turkey flavor, control, and hormonized with added fat as the most flavorful. (See page 231).

Objective tests — *Firmness of canned snap beans*

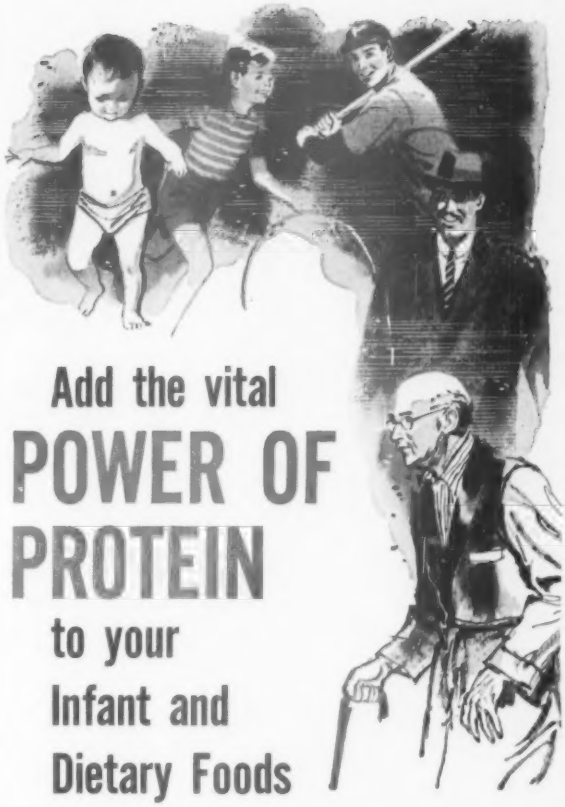
Influence of blanching conditions on sloughing, splitting, and firmness of canned snap beans. J. P. Van Buren, J. C. Moyer, D. E. Wilson, W. B. Robinson, and D. B. Hand.

Objective tests have been developed to give quantitative measures of the firmness of canned snap beans and their tendency to slough and split. These methods have shown that the blanching temperature was one of the most important factors affecting the sloughing of beans. Beans were blanched at temperatures between 150° F and 210° F with the result that, as the temperature was raised, the tendency to slough and split increased and the firmness decreased. When blanching was carried out at temperatures below 180° F increased blanching time led to less sloughing, while at higher blanching temperatures greater sloughing was the result of longer blanching times. The general firming effect of moderate temperature blanching continued to take place during the interval between blanching and retorting and was enhanced by holding the blanched beans at slightly elevated temperatures. Little or no change in firmness took place during holding periods following blanching at 190° F or higher. The tendency of beans to slough was increased by soaking them in oxalate and Calgon solutions prior to blanching, while this tendency was decreased by soaking in a calcium chloride solution. (See page 233).

Palatability tests — *Use of orthogonal polynomials*

Application of orthogonal polynomials to data on palatability. Jacob N. Eisen, Albert B. Parks, and Elsie H. Dawson.

The purpose of this paper is to illustrate the use of orthogonal polynomials with data on palatability in determining the simplest curve that appropriately represents the regression of one variable on another. In this example the values of the independent variable are equally spaced. A brief review of the method of orthogonal polynomials is first presented. The example illustrates how the sum of squares for "between cooking times" is partitioned into independent sums of squares for linear, quadratic, and cubic components of regression. It also shows how orthogonal polynomials are applied in calculating the quadratic regression equation, $\hat{Y} = 10.53 - 1.103X + .039X^2$, for estimating scores for texture from various cooking times (minutes). Orthogonal polynomials constitute a con-



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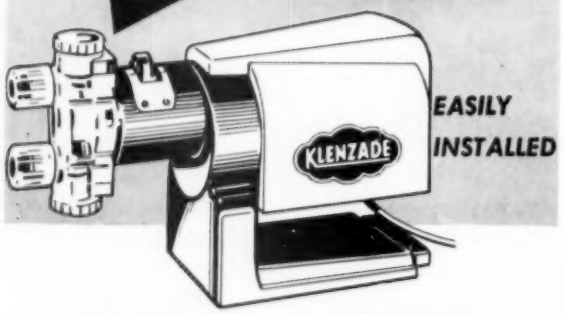

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venient method for determining the goodness of fit of a straight line, quadratic, or higher degree regression curve to data on palatability and to other types of data. The method is useful in non-linear regression involving two variables. By using orthogonal polynomials, the regression equation does not have to be recomputed whenever other terms are added. (See page 237).

Military rations — *Effect of heated water on dehydrates*

The compatibility of dehydrated army rations with chlorinated and iodine-treated surface waters. Morris R. Rogers, Arthur M. Kaplan, and Elizabeth Pillion.

It may be concluded that no particular combination of water and halogen with any of the dehydrated foods used in this study could be regarded as unacceptable even though some of the combinations had a real effect on reducing the excellence of the flavor of the foods. Since none of the average scores fell into the hedonic *dislike* category or below, it must be assumed that the flavor of all the samples was satisfactory under the conditions of the experiment. The use of the average hedonic value had practical and valid application throughout the course of this study as is evidenced by the number and relatively constant results obtained in these tests. (See page 240).

Color evaluation — *Capsicum spices*

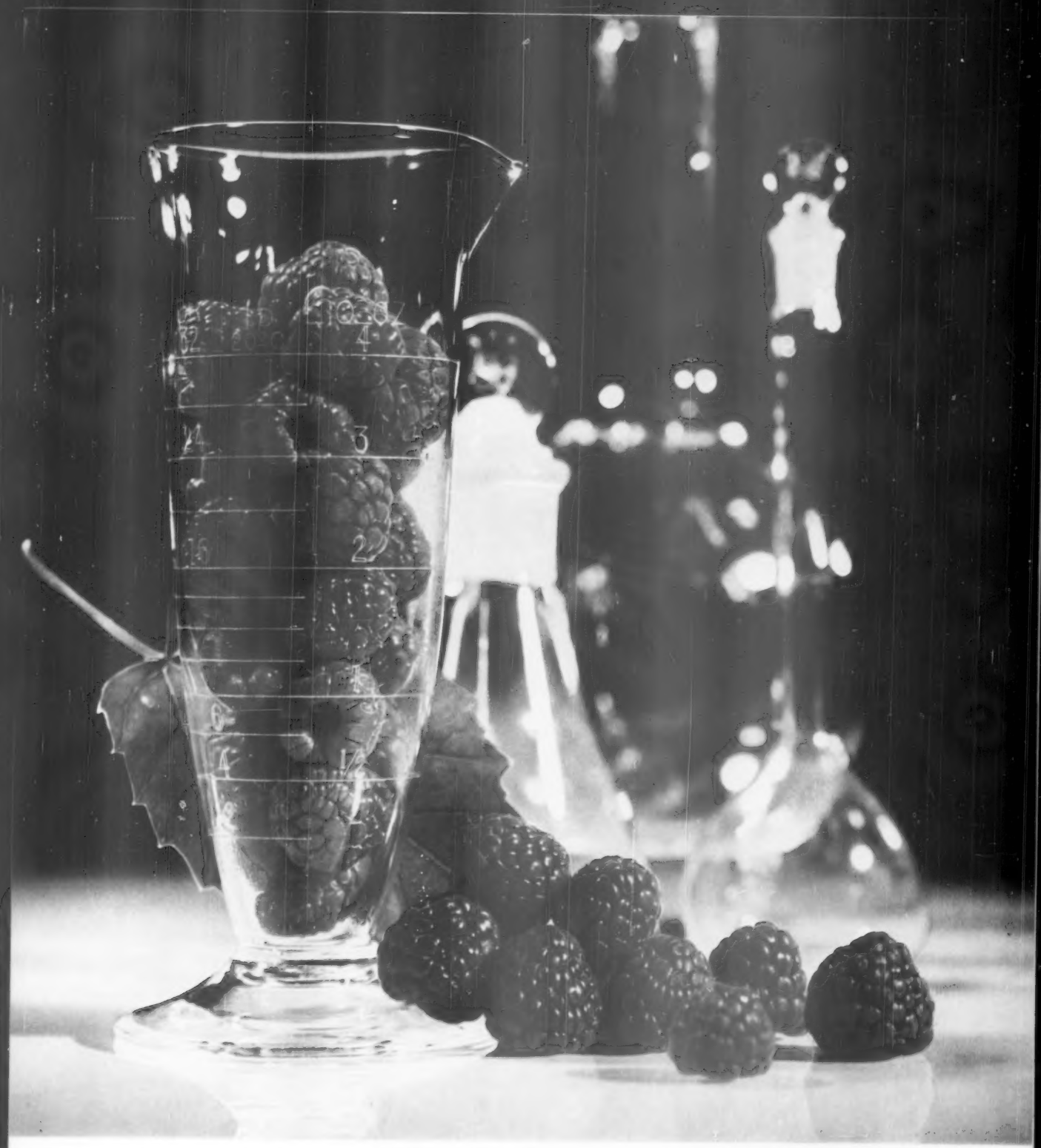
Color of capsicum spices. W. D. Pohle and R. L. Gregory.

The methods usually employed for evaluating the color of capsicum spices are visual methods based upon comparison of the color of a diluted extract with that of a specially prepared potassium dichromate-cobaltous chloride solution or with combinations of Lovibond glasses that match the color of the solution. Visual methods are always subject to personal factors and the difficulties of comparing the color of the extract with that of the standard solutions or color glasses. These usually differ somewhat in hue or chromaticity. Recently, spectrophotometric methods have been proposed. A spectrophotometric method has been proposed by the authors for evaluating the coloring matter of paprika, oleoresin of capsicum and similar products. Better agreement among laboratories is expected by this method as the instruments are calibrated using pure beta-carotene. The color is expressed as micrograms of carotene per gram of sample. Beta-carotene has color characteristics similar to the coloring matter of capsicum and paprika. (See page 245).

Gas chromatography — *Off odors in milk*

Gas chromatography as a means of detecting odors in milk. J. D. Wynn, J. R. Brunner, and G. M. Trout.

Gas chromatography was utilized to show the effectiveness of vacuum pasteurization as a means for removing the volatile feed flavors from milk. Approximately 85% of the measurable flavor components of milk were removed by the vacuum pasteurization process with a resulting one-to-two point increase in flavor score. Characteristic gas chromatograms were obtained for the volatiles in milk from cows fed alfalfa silage, onion tops, or beet tops. Gas chromatography offers a valuable tool for the study of the effectiveness of deodorizing equipment as a means of removing the volatile flavor components of milk. (See page 248).



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Radiation preservation *Fish*

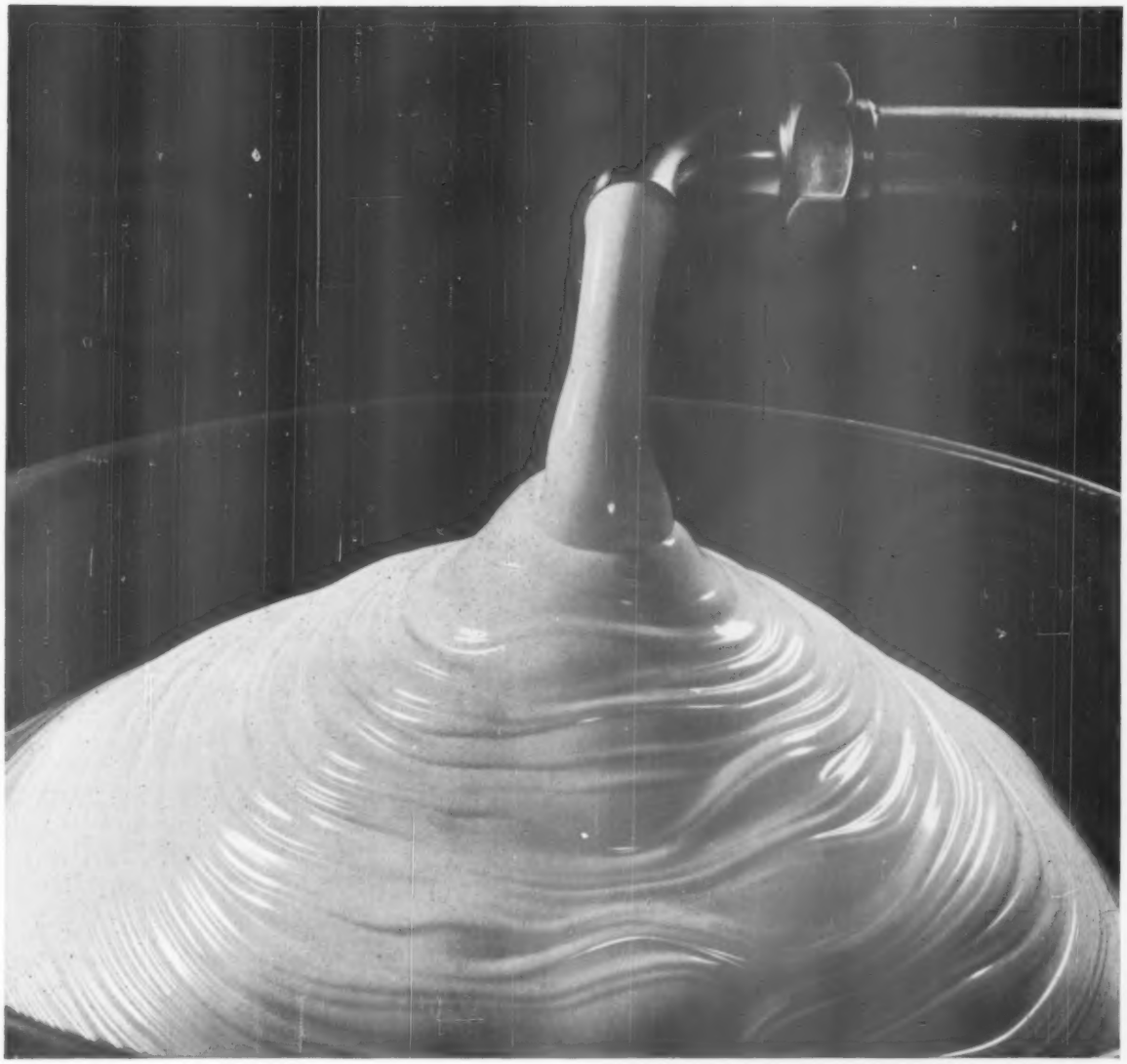
The preservation of fish with ionizing radiation: bacterial studies. Donald P. MacLean and Camille Welander.

The present study was undertaken to determine the effects of ionizing radiation at various levels on the bacterial flora of fillets of Pacific cod *(Gadus macrocephalus)* during storage in melting ice (0° C). The principal objectives were: 1. To compare bacterial counts of unirradiated and irradiated fillets. 2. To identify bacterial genera present before and after irradiation and during storage. 3. To estimate relative numbers of bacteria generically at various levels of irradiation and intervals of storage. 4. An incidental study of micrococci present to assess their potential as food poisoning organisms. Irradiation of cod fillets at relatively low levels of gamma irradiation prolongs the bacteriological storage life at 0° C and appears particularly effective against the genera usually associated with the production of offensive odors characteristic of typical spoilage. In unirradiated control samples the genera *Micrococcus, Achromobacter, Flavobacterium,* and *Corynebacterium* predominated while *Sarcina, Pseudomonas, Alcaligenes, Mycoplana, Protaminobacter, Bacillus,* yeast *(Torulopsis), Aerobacter,* and *Streptococcus* were in minor numbers. Irradiated samples showed predominant genera to be *Micrococcus, Sarcina, Achromobacter, Flavobacterium,* and *Corynebacterium* while *Alcaligenes, Bacillus,* yeast *(Torulopsis),* and *Mycoplana* were less numerous. Organisms of the genus *Micrococcus* appear to be resistant to radiation under conditions of these experiments. However the *Micrococcus* found do not appear to be typical food poisoning organisms. (See page 251).

Technology *Frigi-canning*

Frigi-Canning. Edward F. Kohman.

"Frigi-Canning" is the preservation of food by enough heat to kill vegetative microorganisms, hermetically sealing under aseptic conditions, and holding at the lowest possible temperatures without freezing. The author of this note comments that the home gardener, without canning equipment of any kind, but with some refrigeration space, could, by "Frigi-Canning," do considerable to make use of his surplus. Also the city dweller on his week-end drive could pick up at low cost a hamper of his favorite vegetable and by this method enjoy it for a considerable time. The favorable results that have been obtained indicate there may be a much more extensive possibility. Even now canned whole hams may be regarded as being Frigi-Canned. Originally there was strong opposition to freezing vegetables in hermetically sealed cans for fear they might be allowed to be held under conditions favorable to the development of *Cl. botulinum.* Now a wide variety of products that one would regard as excellent media for this organism are frozen in hermetically sealed cans. Consumer education is a part of any successful distribution. Even fresh milk, a good medium for *Cl. botulinum,* is distributed under poorer refrigeration than one would expect for Frigi-Canning. A canner serving large users, such as restaurants and hotels and reprocessing manufacturers, could easily observe and supervise the refrigeration of Frigi-Canned products. To be sure, anyone would be remiss and foolish not to give the matter *technical study under his own conditions before doing Frigi-Canning on a large scale.* (See page 254).



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IFT News

1960 Election of IFT Officers

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COUNCILORS-AT-LARGE:

Mr. Carlos A. Greenleaf, Washington, D. C. Section

Dr. Hans Lineweaver, No. Calif. Section

Dr. Reid T. Milner, Chicago Section

Dr. Herbert E. Robinson, Chicago Section

S. CALIFORNIA

Southern California Sections IFT'ers had to move into the large ballroom at Roger Young Auditorium to accommodate the capacity crowd that turned out to hear Institute President-Elect Dr. I. J. Hutchings discuss some of the problems that face food technologists today. Preceding Dr. Hutchings' talk, Southern Section Chairman, Gordon Miller, informed the group that the executive committee had approved a donation of $100.00 to the Dr. Ernest Geiger Memorial Fund at the University of Southern California. He also presented a scroll and pocket secretary to Henry Espoy as a memento of his excellent year as chairman in 1959.

Dr. Hutchings, Institute President-Elect, is manager of Food Research, H. J. Heinz Company, Pittsburgh, Pennsylvania. He is in charge of administrating and directing all research activities in plant breeding, horticulture practices, bacteriology and nutrition, experimental product development and food technology. He chose as his topic of the evening "Food and the Food Technologist."

Dr. Hutchings informed the group that one of the major problems facing food technologists now and in the future is the increase in population. In his opinion the responsibility of all food technologists is to give this increased population of the future a product of the highest nutritional value, quality, and appearance, doing this work in a way that will represent a profit to the organization they are representing. Dr. Hutchings went on to say that there is no such thing as a "quality" product if that product does not meet with absolutely all specifications and that it was up to the food technologists to obtain materials and maintain procedures that will give these necessary specifications and therefore *quality* to their product.

—*D. K. Wright*

NORTHEAST

The annual Students' Night Dinner and awards were held on March fifteenth, at the M.I.T. Faculty Club. More than 140 members and student guests attended. The following students were recipients of awards:

Maynard R. Johnson received the Alexander E. Katz Memorial Scholarship presented by I. W. Zanger of the F. Ritter Co.

Edward Weiss received the Dodge and Olcott Award presented by Jules Bauer of Dodge and Olcott.

Daniel Farkas received the General Foods Award presented by Dr. Domenic DeFelice of General Foods Corp.

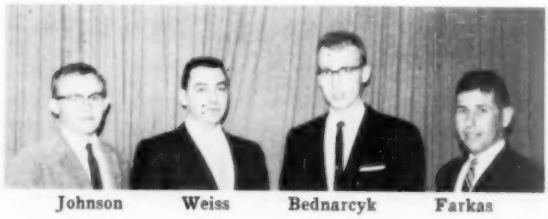
Norman Bednarcyk received the Gerber Award presented by Dr. William B. Esselen for the Gerber Products Co.

We congratulate these young Food Scientists on their outstanding achievements.

Annual elections were held resulting in the following new officers:

Chairman: Mr. Norman W. Kaupf, Walter Baker Div., General Foods Corporation.

Vice-Chairman: Dr. John T. R. Nickerson, Mass. Inst., Tech.



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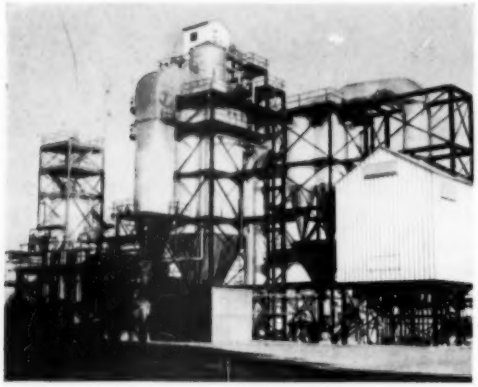

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The guest speaker for the evening, Dr. I. J. Hutchings, President-Elect of the IFT, gave a most stimulating talk on the responsibilities of the Institute of Food Technologists and the Food Scientist in view of the rapidly expanding world population. Emphasis should be placed more on efficient food production of improved quality and nutritional value, than on tonnage per se. Food Technologists also have a responsibility for public eduction as to the basically high quality and safety of our food supply, and for publicizing the fact that the food industry is striving for continued improvements in these areas.

The Food Technologist has finally come into his own during the past few years. The establishment of a standard curriculum of study for food scientists is a step forward. Another area where improvement is essential is in the caliber of papers presented in Food Research, Food Technology, and at the annual meeting. This will receive considerable attention by Dr. Hutchings during the coming year.

—*Donald E. Westcott*

NEW YORK

Food packagers and packaging suppliers will henceforth be doing business on a day-to-day basis, Lloyd Stouffer, editor of *Modern Packaging*, told the New York section of the Institute of Food Technologists at their March meeting. The only solution is postponement of the March 5, 1960, deadline. (Late word has it that postponement was authorized in early April. Details regarding postponement are given in the April issue of *Modern Packaging*).

According to *Modern Packaging's* compilation, F&DA has classified less than two-thirds of the 1,000 chemicals important in packaging, Stouffer told the group. Most of these are listed in the "test extension" category. The law gives them a lease on life for one year as a maximum; they may be cut off this list at any time. Meanwhile, more than 300 chemicals remain unclassified, although they are not specifically black-listed either. Under the Food Additives Amendment, food packagers are prohibited from using packaging materials that are not cleared by F&DA.

On the other hand, F&DA is apparently no less confused than the packaging industry. One chemical, magnesium stearate, has been so thoroughly classified that it appears in all three categories and is "either cleared by prior sanction, cleared by general opinion, or not cleared at all, depending on how you look at it," Mr. Stouffer pointed out.

In addition to the difficulties of doing business under the Federal law, which applies only to products in interstate commerce, there is a move to supplement it with similar laws in each of the 50 states, such as the Metcalf bill in New York.

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"Now if the state bills conform exactly with the Federal law, there will be no great problem," Mr. Stouffer said.

"But you can well imagine the headaches if you have to package for 50 states under 50 different sets of rules."

It is also possible that food packagers will be asked to give retailers guaranties of compliance, which at this point would be nearly impossible. There is a move afoot among supermarket operators to ask food packagers for guaranties against customer claims growing out of non-compliance with F&DA regulations.

OHIO VALLEY

The Ohio Valley Section held its Winter meeting at the Ohio State University with approximately 80 persons attending the afternoon session, and 95 members and guests present for the dinner and evening session.

Letters were read by President Radcliffe Robinson dealing with a proposal for formation of a new "Blue-Grass Section" with headquarters in Louisville, and also from President Wakefield concerning the Pacific Rim Food Conference which follows the IFT Meeting in San Francisco. The Section voted to support the action of the IFT Executive Committee concerning plans for working with the Society of Chemical Industries in London, England, on a meeting in 1962.

Speakers for the afternoon were: Dr. Raymond H. Blackmore, Ohio Department of Agriculture; Dr. J. B. Brown, Director of the Institute of Nutrition and Food Technology, and Chairman of the Department of Physiological Chemistry at Ohio State University; Dr. W. E. Krauss, Ohio Agricultural Experiment Station. Dr. Blackmore, discussing the subject, "A Food Technologist's Role in Consumer Protection" pointed out that his department is charged with enforcement of twenty-eight specific laws, and is doing the best it can with a staff that is "wholly inadequate." Federal and State laws are only as effective as the enforcement provided, and technical assistance is imperative at the processor's plant and at the enforcement agency if the consumer is to obtain wholesome, unadulterated, and standardized food. "Consumer and industry alike expect regulatory agencies to prosecute the non-conformists," Dr. Blackmore concluded. "Regulatory agencies, in turn, must be supported financially by both industry and consumers."

Dr. Brown, in considering his topic "Obligations of the Food Technologists to the Consumer," suggested the following as some of these "obligations": A thorough knowledge of composition of the food products with which he deals; knowledge of the effects of processing on these products; awareness that the nutritive value of products will never exceed the nutritive values of the raw materials used; understanding of the nutrients in foods and their metabolic functions; familiarity with the background of the problem of cardiovascular disease; discouragement of misleading and extravagant claims; thorough familiarity with problems of cleanliness, food additives, spray residues; creation of new and attractive products.

Dr. Krauss spoke on the topic, "Food Production for Health" and pointed out that it has been established that food does contribute to physical, mental, and emotional health, and that while there still is some malnutrition in this country, it is due more to ignorance and apathy than to a deficient food supply. He observed that good nutrition is the best guarantee of an able, energetic, long-lived population, and this requires emphasis on research and education in nutrition, since good nutrition comes as each family and individual knows what is desirable.

The dinner speaker was Dr. I. J. Hutchings, President-Elect of the IFT, who discussed the timely subject, "Industry's Point of View on Recent Food and Drug Administration Actions." Regulatory laws are necessary because there are some individuals and companies in the food industry that are not "imbued with the spirit of public responsibility." It is important, however, to distinguish between "hazard" and "toxicity" in providing regulations to control potential health hazards. And it is up to each of us to advise our representatives in Congress what we believe should be done with this legislation.

WISCONSIN

The 1960 meeting schedule of the Wisconsin Section opened with a gathering of 80 members in Madison on March 25. Afternoon tours were held at the

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facilities of the American Breeders Service and the American Foundation for Biological Research.

Following dinner and a brief business session, Father B. Luyet, Director of the American Foundation for Biological Research, spoke "On the Operation of the Freezer: A Glance at the Mechanisms of Freezing at the Magnification of 10,000,000 Times." His discussion was highlighted by slides and movies of the size, shape and rate of formation of ice crystals in aqueous solutions and biological tissue.

The section will next meet in LaCrosse on April 29 for a tri-state meeting with the Iowa and Minnesota sections. On May 27, the spring activities of the section will close with a meeting at Manitowoc which will include tours of the Wisconsin Malting Company and the White House Milk Company.

DIXIE

The Dixie Section held a dinner meeting on March 4, as the concluding event of the Second Southeastern Conference on Better Foods for Better Nutrition at the University of Georgia Center for Continuing Education in Athens. Many of the section members attended the entire two-day conference, and those present on the second day had the privilege of hearing a series of three addresses by Dr. Charles Glen King, Executive Director of the Nutrition Foundation and Professor of Chemistry at Columbia University. Dr. King discussed first the development and present status of food fortification in relation to American and world dietary needs and habits, relief and prevention of definite nutritional deficiencies, and current trends in promotional advertising and foods legislation. The second talk concerned problems of establishing native programs of food production, education and medical assistance to provide at least survival levels of child and adult nutrition among grossly undernourished populations. Dr. King illustrated accomplishments in these areas with colored slide photographs which he has taken on recent United Nations missions to Guatemala, Brazil, and India. For his third address, Dr. King summarized the role of the Nutrition Foundation in relation to the subjects discussed in the preceding talks and to past and present research in biochemical aspects of nutrition. Particular emphasis was placed on the public health and food technological implications in current research trends in the fields of fat and protein metabolism.

—H. Ray Malcom

WASHINGTON, D. C.

About 60 members met in the NCA building the evening of March 30. New committees were appointed by Chairman Reynolds during the business meeting and considerable discussion held on what action the education committee might take to meet the Section's responsibility in interesting new students in the profession. The National society's actions were reviewed for purposes of guidance of the local section.

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food technology, as explained by three speakers. S. R. Hoover, Asst. Adm., Utilization Research, U.S.D.A. discussed research being done in federal government laboratories. These include the four Utilization laboratories, the Institute of Home Economics and two research divisions of the Agricultural Marketing Service. R. G. Garner, Food Technologist, Office of Expt. Stations, U.S.D.A., explained those research programs of the State experiment stations which are carried on with the aid of federal grants. This is also a very broad and comprehensive program. I. I. Somers, Director of Research Labs., N.C.A. discussed research work being carried on by food trade associations, with natural emphasis on the program of the National Canners' Association, which is carried out principally in the three NCA laboratories.

Program Chairman Amihud Kramer provided the membership with dates and subjects of meetings for the balance of the year. For the benefit of any "visiting firemen" the following meetings will not require reservations: Sept. 28 (on Frozen Foods); Oct. 26 (on Fish Technology); Nov. 30 (Prexy Hutchings). Meetings are held at the NCA building.

FUTURE MEETINGS FOR FOOD TECHNOLOGISTS

1960	
May 9-11	Conference on Gas Chromatography for Analytical Chemists in the Food Industry, Memorial Center, Purdue University
May 15-19	**Twentieth Annual Meeting of the Institute of Food Technologists, Fairmont Hotel and Masonic Temple, San Francisco, California**
May 19 to May 25 or 29	**IFT Pacific Rim Food Conference, Princess Kaiulani Hotel, Honolulu, Hawaii**
June 6-10	National Confectioners Association Convention, and Confectionery Industries Exposition, Philadelphia, Pennsylvania
June 8-10	The 3rd Symposium on Gas Chromatography, Assembly Rooms, Edinburgh, Scotland
June 9-10	Third Annual Conference, Canadian Institute of Food Technology, Royal Alexander Hotel, Winnipeg, Manitoba
June 13-September 2	Gordon Research Conferences, New London, New Hampshire
June 14-16	The Canadian Dietetic Association, Queen Elizabeth Hotel, Montreal, Quebec
August 29-September 9	Second International Course on Lyophilization, Lyon, France
September 1-7	Fifth International Congress on Nutrition, Washington, D. C.
September 20-23	Pure Food Centenary, Royal Institution of Great Britain, London, England

1961	
May 7-11	**Twenty-first Annual Meeting of the Institute of Food Technologists, Hotel Statler, New York, New York**
1962	
June 10–14	**Twenty-second Annual Meeting of the Institute of Food Technologists, Fontainebleau Hotel, Eden Roc Hotel, Miami Beach, Florida**
1963	
May 19–23	**Twenty-third Annual Meeting of the Institute of Food Technologists, Pantlind Hotel, Civic Auditorium, Grand Rapids, Michigan**

An open invitation is extended to readers of FOOD TECHNOLOGY to send in to the Editorial Office, 11606 South Bell Avenue, Chicago 43, Illinois notices of annual or national meetings of interest to food technologists.

Literature

LITERATURE ON FOOD RESEARCH AND TECHNOLOGY*

General

Handbook of cane sugar engineering. E. Hugot (tr. G. H. Jenkins) Elsevier, New York, 1960.

Igiene e industrie dell'alimentazione: l'alimentazioine del lattante, rinvigorimento biologico, differimento calla senescenza, le carenze vitaminiche, le deviazioni dismetaboliche, le industrie alimentari. By Giulio Buogo. Milano, Casa editrice Ceschina, 1958. 495 p., tables.

Introduction to foods and nutrition. Gladys T. Stevenson and Cora Miller. New York, Wiley, 1960. 517 p. illus.

Modern refrigeration and air conditioning, by Andrew D. Althouse and Carl H. Turnquist. Chicago, Goodheart-Willcox Co., 1960. 756 p., illus.

Principles and procedures for evaluating the safety of food additives. Publ. 750. Food Protection Committee, Food and Nutrition Board, National Research Council, Washington, D. C.

Survey of food industry and food processing in Eastern Europe, by George J. Malecki. Research Document No. 334 of the Free Europe Committee's Mid-European Studies Center, available only on film from the Photoduplication Service, Library of Congress, Washington, D. C.

Chemistry and Analysis

Evaluating soybeans by dielectric analysis and other methods, by Harland N. Doughty. U. S. Department of Agriculture Marketing research report No. 367, 1959. 36 p.

Grundriss der technischen Chemie. Carl Kröger. Göttingen, Vandenhoeck & Ruprecht. Vol. 1, part 5, 1958. Technische Pflanzen- und Tierstoffchemie.

Poliarograficheskii analiz. [Polarographic analysis] by T. A. Kriukova and coworkers. Moscow, 1959. 772 p., illus.

X-ray spectrochemical analysis. New York, Interscience publishers, 1959. 137 p., illus.

Fruits and Vegetables

Maturation of green stringless bush beans, by P. W. Board & G. G. Coote. Melbourne, Australia, Commonwealth Scientific and Industrial Research Organization, Division of Food Preservation and Transport, Technical Paper no. 12, 1959. 12 p.

Physical and chemical changes during the ripening of tomatoes as affected by temperature, by H. M. Moghrabi. Thesis, University of Illinois, available from University Microfilms, Ann Arbor, Michigan. 65 leaves.

The production of mahewa. F. Schweigart, W. E. L. Van Bergen, S. A. Weichers, and J. P. DeWit. National Nutrition Research Institute. C.S.I.R., Pretoria, South Africa. 1960.

U. S. Standards for grades of canned grapefruit and orange for salad. U. S. Agricultural Marketing Service, Washington 25, D. C., 1960. 6 p.

Meat and Dairy Industry

Compression of dehydrated mutton and beef mince, by A. R. Prater, G. G. Coote and E. A. Roberts. Melbourne, Australia, Commonwealth Scientific and Industrial Research Organization, Division of Food Preservation and Transportation, Technical Paper no. 13, 1959. 26 p.

Die Kostenstruktur der Käse erzeugenden Betriebe im Allgäu, unter besonderer Berücksichtigung der Fertigung von Naturkäse. Thesis, University of Munich, 1953. 145 leaves. Carbon

(Continued on page 21 following Technical Section)

* Material for this list should be sent to Walter L. Necker, Librarian, Quartermaster Food and Container Institute for the Armed Forces, 1819 W. Pershing Road, Chicago 9, Illinois.

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(Continued from page 20 preceding Technical Section)

copy of the dissertation available at the Library of Congress, by Hans Häring.

Sanitariia i gigiena v miasnoi i molochnoi promyshlennosti, by E. I. Volpin. Moscow, 1953. 122 p. Sanitary and hygiene procedures in the meat and dairy industry.

USSR Ministerstvo promyshlennosti miasnykh i molochnyckh produktov. Trudy. Uglich. The first volume of collected papers on cheese appeared in 1951; the series is still open.

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Nutrition books for lay readers; a guide to the reliable and the unreliable, by Helen S. Mitchell. Library Journal, Feb. 15, 1960, vol. 85, p. 710–714. Lists 27 reliable and 14 "unreliable" items, based wholly on professional reviews in medical, public health, and food journals.

Science abstracts of China (No. 1, 1958). Institute of Scientific Information, Academia Sinica, 117 Chao Yang Men St., Peking, China.

Analysis and Adulteration

Bewährte Untersuchungsmethoden, by Helmut Aberham. Vienna, Victoria Verlag, 1959. 71 p., illus. Grading and analysis of grain.

Principles and procedures for evaluating the safety of food additives. Washington, National Academy of Sciences-National Research Council publication 750, 1960. iii, 9p.

Problems in the evaluation of carcinogenic hazard from use of food additives. National Academy of Sciences-National Research Council publication 749, 1960. v, 44 p. $1. paper

Die Untersuchung von Tieren stammender Lebensmittel; eine Anweisung für die tierärztliche Praxis im Aussendienst und im Laboratorium, by F. K. Schönberg. 7th ed. Hannover, M. & H. Schaper, 1959. 532 p., illus.

Products

Analyse et contrôle des vins, par Jean Ribéreau-Gayon et E. Peynaud. 2nd ed. Paris, C. Béranger, 1958. 557 p., illus.

Behavior of color in beets, by Edmund W. Lusas. Thesis, University of Wisconsin, 1959. xv, 278 p., illus. Microfilm available from University Microfilms, Ann Arbor, Mich.

Kaffee, Kakao, Tee, von Hans Spriestersbach. Hamburg, Cram, DeGruyter, 1959. 160 p., illus.

Microbiology of citrus fruit processing, by Roger Patrick and Elmer C. Hill. Florida Agricultural Experiment Station Bulletin 618, 1959. 62 p., illus. Includes an excellent bibliography of 146 titles.

Poultry hygiene, part 1. Examination and evaluation of poultry and poultry products. Public Health Service publication 683, 1959. vii, 55 p. paper. (Available from U. S. Superintendent of Documents for 40 cents).

Studies related to the reconstitutability of dried whole milk. Thesis, University of Wisconsin. v, 113 p., illus. 1959. Microfilm available from University Microfilms, Ann Arbor, Mich.

Vinos: elaboración, análisis, tratamientos. por Luis Durán Massó. Barcelona, Serrahima y Urpi, 1959. 364 p., illus.

Miscellaneous

Arbeitsstoffpaare (Arbeitsmittel und Absorptionsmittel) für Absorptions-Kälteanlagen und Absorptions-Kühlschränke . . . von Wilhelm Niebergall. Mühlhausen/Thür., Verlag für Fachliteratur R. Markewitz, 1959. 269 p.

Bonbon und Dragéeherstellung; allgemeine Grundlagen, Rohstoffe, Maschinen, Arbeitsanleitungen. von Fritz Münchow. Leipzig, Fachbuchverlag, 1959. 256 p., illus.

The chemistry of a thermally oxidized oil, by Edward G. Perkins. Thesis, University of Illinois. v, 84 p., illus. 1958. Microfilm available from University Microfilms, Ann Arbor, Mich.

Konservirovanie plodov i ovoshchei v domashnikh usloviiakh, by A. F. Namestnikov. Moscow, 1959. 213 p., illus. On canning and preserving.

La nuova enologia; trattato di scienza enologica applicata alla tecnologia e all'analisi del vino. Firenze, Istituto di industrie agrarie, 1959. 1359 p.

Soviet research in glass and ceramics, 1956. English translation, New York, Consultants Bureau, 1959. 323 p., illus.

Technologia delle spezie, by Antonio Ferrara. Firenze, Istituto agronomico per l'Oltremare, 1958. 121 p.

West Africa's fats and oils industry, by Calvin C. Spilsbury. U. S. Foreign Agricultural Service, FSA-M-62, 1959. 42 p.

ABSTRACTS

General Foods Research Center
Selected by H. A. Campbell

ANALYTICAL METHODS

Mass spectrometric analysis. Rearrangements in vinyl derivatives.

McLafferty, F. W. (Dow Chem. Co., Framingham, Mass.). *Anal. Chem. 3*, 2072–5 (1959).

The typical rearrangement found in the mass spectra of polar unsatd. compds. can also explain major anomalous peaks in vinyl ethers, vinyl esters, and olefins. It accounts for almost all base peaks of even *m/e* in olefin spectra. Rearrangement of one (and sometimes two) protons through a six-membered ring intermediate is used to interpret the effects of substitution.

Determination of citral in lemongrass and citrus oils by condensation with barbituric acid.

Levi, L. and Laughton, P. M. (Carleton Univ., Ottawa, Can.). *J. Agr. Food Chem. 7*, 850–9 (1959).

When the α,β-unsatd. aldehyde is treated with barbituric acid in aq. ethyl alcohol, condensation takes place to form citrylidenebarbituric acid. The reaction product displays strong ultraviolet absorption at 336 mμ, and the intensity of the band observed at this wave length, under controlled conditions, is utilized for quant. measurements. The method should prove useful to the essential oil, flavor, and cosmetic industry.

Quantitative determination of flavanones in citrus bioflavonoids by potassium borohydride reduction.

Rowell, K. M. and Winter, D. H. (Sunkist Growers, Ontario, Calif.). *J. Am. Pharm. Assoc. 48*, 746–9 (1959).

Flavanones reduced with potassium borohydride and acidified with hydrochlorie acid develop red to violet colors. This reaction forms the basis for a quant. spectrophotometric method for the detn. of flavanones. The procedure outlined is sufficiently sensitive to det. quant. solubilized flavanones at concns. of 0.02 mg./ml.

Spectrophotometric determination of α-tocopherol.

Lambertsen, G. and Braekkan, O. R. (Norwegian Fisheries Research Inst., Bergen). *Analyst 84*, 706–11 (1959).

A method for the detn. of α-tocopherol in oils and foods is described. The principle of the method is sapon. of the sample and extn. of the unsaponifiable matter, adsorption chromatography on a column of alumina, partition chromatography of the α-tocopherol fraction on strips of paraffin-impregnated paper in a horizontal jar and measurement of the extinction of the α-tocopherol fraction and calcn. of the potency by a geometric correction procedure. The method is specific for α-tocopherol.

BIOLOGICAL SCIENCES

Biochemistry

The composition of plum gums.

Hough, L. and Pridham, J. B. (Univ. of Bristol, Engl.). *Biochem. J. 73*, 550–9 (1959).

The composition, function and formation of gum has been studied with par-

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ticular reference to the plum tree. The polysaccharide moiety of the gum exuded on the fruit surface was composed of D-galactose, D-mannose, L-arabinose, D-xylose, L-rhamnose, glucuronic acid and probably traces of 4-*O*-methylglucuronic acid. The bark gum was similarly constituted but contained higher proportions of D-mannose, L-arabinose and hexuronic acid. Periodate oxidation of the two types of gum suggested structural differences though their electrophoretic mobilities were identical.

Chemical properties of two mucoids from bovine cervical mucin.

GIBBONS, R. A. *Biochem. J. 73*, 209–17 (1959).

A method for the isolation of undegraded mucoid from bovine cervical mucin is described. The mucoids were found to consist of 75–80% of carbohydrate and 20–25% of amino acid residues, and to behave chemically in a manner similar to the human blood-group substances. The results of hydrolysis of oestrous mucoid in 0.1*N* HCl at 20° suggest that part of the sialic acid is present as end group and that the sialic acid content is one of the factors affecting the physical properties of mucin.

An instrument and technique for the continuous measurement of respiratory CO_2 patterns in metabolic tracer studies.

DOMINGUES, F. J., ET AL. (General Foods Research Center, Tarrytown, N. Y.) *Intern. J. Appl. Radiation and Isotopes 7*, 77–86 (1959).

An instrument has been developed for the continuous analysis and recording of respiratory CO_2 to facilitate metabolic tracer studies with rats. This instrument measures radioactive CO_2 by means of a vibrating reed electrometer and total CO_2 by means of infrared absorption. Specific activity is recorded separately. A linear integrator makes it possible to read total respired radioactive CO_2 at any point in a metabolic experiment.

Effect of protein depletion on the distribution of protein synthesis.

WATERLOW, J. (Univ. of the West Indies, Jamaica). *Nature 184*, 1875–6 (1959).

In order to test Garrow's hypothesis that in protein depletion the synthesis of protein is coned. in the more essential organs at the expense of the others, organs of protein depleted and control rats were analyzed for radioactivity after injecting of methionine labelled with S-35. The animals were sacrificed at intervals of 1, 2, 3, 5, and 7 days. Radioactivity was greater in the viscera of protein depleted rats than in normal animals; conversely the activity in skin was less in depleted than in normal. In protein-deficient rats the incorporation of labelled amino acid was much less in muscle and in skin in relation to that of serum. Several explanations for this phenomena are advanced.

Microbiology

Effect of heat treatment on the growth of surviving cells.

KAUFMANN, O. W., ET AL. (Michigan State Univ., East Lansing). *J. Bacteriol. 78*, 834–8 (1959).

Heated cells of a heat-resistant Micrococcus strain MS 102 exhibit a longer lag phase of development than do unheated cells when the initial cell levels are equal. At an initial cell population of 2000/ml., the lag phase of development is increased from 22 to 40 hrs. when the heating treatment is changed from 76 ±1° C. for 17 sec. to 82 ±1° C. for 5 ±1 sec. At an initial cell population of 20,000/ml. the lag period increased only from 19 to 25 hr. under the above temp. changes.

Toxicity enhancement of Clostridium botulinum type A and B culture filtrates by proteolytic enzymes.

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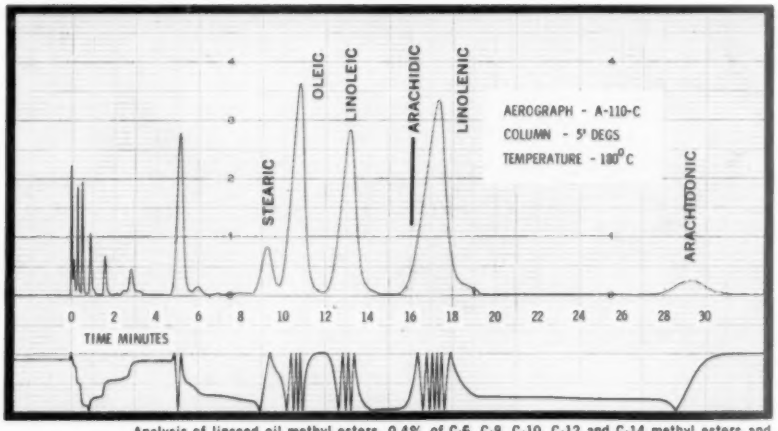

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Convection in Syrup-Packed Products[a, b]

R. C. Nicholas, I. J. Pflug, and T. R. Mulvaney

Agricultural Engineering Department, Michigan State University, East Lansing, Michigan

(Manuscript received May 21, 1959)

PROBLEMS ENCOUNTERED in heating syrup-packed products have a long history. The difficulty of heating these products is well established. When solids such as fruits and vegetables are placed in a liquid, the solids heat by conduction, and the assumption is usually made that the liquid heats by convection, commonly acknowledged to be a more rapid method of heat transfer than conduction. However, there are notable instances in which heating does not proceed as rapidly as expected. Braun *(7)* and Braun, Hays, and Benjamin *(8)* report the results of adding dry sugar to cans of sweet potatoes. Excessive spoilage in these packs was attributed to the failure of the sugar to dissolve completely with a resulting retardation of normal convection currents.

The higher viscosity of syrup, compared with water, has been suggested and investigated as the source of the difficulty of heating syrup-packed products *(5, 9, 10, 12, 14)*. That increased viscosity retards convection to some extent is not questioned. Nevertheless, the results of these studies, which include determinations of the heating of pure syrups of various concentrations and comparisons of the heating of foods packed in water with the same foods packed in syrup, show that viscosity alone cannot account for the slower heating observed.

It is suggested that the explanation of this problem lies in an analysis of the liquid and soluble solids exchanges taking place between product and covering liquor. These exchanges, during which the soluble solids contents of product and liquor approach equilibrium, are known to take place over a period of time that is long compared with the heat processing time *(1, 4, 6, 11, 15)*. However, after adding syrup to the product, the water leaving the product rises to the top of the container with the result that within minutes appreciable differences in syrup concentration are established between the top and bottom of the container. This phenomenon, called product-induced stratification, will be reported in detail in a subsequent paper *(13)*.

Most analytical treatments of convection heating are restricted to the case of a homogeneous fluid in which the density differences that cause convection are the result of temperature differences only. However, if the fluid is not homogeneous, as is the case when the syrup concentration is not uniform throughout the container, then density differences will be a function of both syrup concentration and temperature. Because the density is a function of these two variables, there can be combinations of syrup concentration and temperature that will prevent convection currents. It is the purpose of this paper to show what combinations of syrup (sucrose) concentration and temperature will prevent convection.

ANALYSIS

The forces of importance for convection acting on parcels of liquid are buoyant forces, gravity, and viscosity. In the case of no relative motion, viscosity may be neglected because the velocity is zero. Viscosity will affect the rate of convection currents, but not the onset of convection.

Consider two neighboring points in a jar, P_1 and P_2 (P_1 above P_2) at which the densities are given by $\rho_1(p_1, T_1)$ and $\rho_2(p_2, T_2)$ where ρ is density, p is the sucrose concentration, and T is the temperature. If $\rho_1 < \rho_2$, then there will be no convective exchange of liquid between these two points; that is, the criterion of no convection is $\Delta\rho_{1,2} \equiv \rho_1 - \rho_2 < 0$ and since

$$\rho = \rho(p,T) \text{ then } \Delta\rho = \left(\frac{\delta\rho}{\delta p}\right)_T \Delta\rho + \left(\frac{\delta\rho}{\delta T}\right)_p \Delta T.$$

$$\Delta\rho_{1,2} = \left(\frac{\delta\rho}{\delta p}\right)_T \Delta p_{1,2} + \left(\frac{\delta\rho}{\delta T}\right)_p \Delta T_{1,2} < 0 \qquad (1)$$

is a restatement of the criterion for no convection.

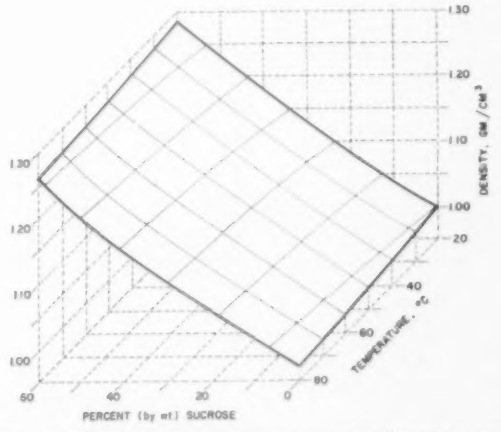

Figure 1. Density of sucrose syrups as a function of temperature and per cent sucrose.

Figure 1 shows the function ρ in the sucrose concentration range of 0–60%, by weight, and the temperature range of 20–80° C (densities taken from reference *3*). This surface was fitted by the method of averages to the equation

$$\rho = a + bp + ep^2 + dT \qquad (2)$$

in which ρ is in g/cm³, p is in %, T is in ° C, $a = 1.016$ g/cm³, $b = 3.96 \times 10^{-3}$ g/cm³/%, $c = 1.24 \times 10^{-6}$ g/cm³/%², and $d = -6.16 \times 10^{-4}$ g/cm³ °C. These constants give errors of about ±0.5% in the concentration and temperature range studied.

[a] Journal Paper No. 2547, Michigan Agricultural Experiment Station, East Lansing, Michigan.

[b] Presented before the Nineteenth Annual Meeting of the Institute of Food Technologists, Philadelphia, Pennsylvania, May 19. 1959.

Differentiation of equation (2) gives $\left(\frac{\delta\rho}{\delta T}\right)_p = d$ (3)

and $\left(\frac{\delta\rho}{\delta p}\right)_T = b + 2ep$ (4)

Equations (3) and (4) substituted in equation (1), which is then solved for $\Delta p_{1,2}$ give $\Delta p_{1,2} < -\frac{d\Delta T_{1,2}}{b + 2ep}$. (5)

Consider a representative acid-food processing condition at the beginning of heat processing, when the temperature difference between product and heating medium is a maximum. Suppose the initial sucrose concentration is 50% in the syrup and essentially zero in the product, and that syrup and product are initially at 20° C. Let the heating medium temperature to which the container is subjected be 80° C. Let P_1 be some point above the bottom of the jar which is still at the initial temperature of 20° C and let P_2 be a point at the bottom of the jar which has reached the bath temperature of 80° C and where the syrup concentration is still 50% sucrose. Substitution of these values of temperature and sucrose concentration in equation (5) gives $\Delta p_{1,2} < -7\%$ or $p_1 < p_2 - 7\%$ or $p_1 < 43\%$ for the criterion of no convection between points P_1 and P_2 as defined. If at the point P_1, still at 20° C, the sucrose concentration has dropped to less than 43%, then convection will not take place even though the temperature of the liquid at P_2 is 60° C higher than the temperature at P_1. Naturally, if ΔT is smaller than 60° C, the Δp required to prohibit convection will be proportionally smaller. Obviously there are unlimited combinations of temperature and percentage sucrose that will prohibit convection between specified points. Only one such combination has been exhibited in order to show the concentration difference required to prohibit convection under the most favorable temperature difference for convection.

DISCUSSION AND CONCLUSIONS

In the present study it has been shown that a difference of 7% in sucrose concentration between two points will prohibit convection between these points even if the heavier syrup is 60° C higher in temperature. Mulvaney, Nicholas, and Pflug *(13)* showed that 2 minutes after processing begins, differences of over 9% in sucrose concentration were found between the top and bottom of jars of sweet fresh cucumber spears. By the end of the heat processing period, this concentration difference had increased to about 15%.

If convection is prevented or inhibited, heating rates, f_h, as defined by Ball *(2)*, can be expected to increase. Table 1 gives representative heating rates of some fresh cucumber pickle products. These data are labeled as representative because many factors, such as pickle-to-liquor ratio, have minor effects on the heating rate. These data, published and unpublished, were taken from the authors' file of the heating rates of these various products. A comparison of the heating rates in these products indicates that the greatest effect is due to the presence of sucrose in the covering liquor. Except for the small, whole cucumber pickles, the addition of sucrose syrup has nearly doubled the heating rates. The exception helps to verify the criterion of no convection. The covering liquor instead of 50% sucrose, was 36%, which equation (5) shows requires a larger Δp to prevent convection. Moreover, at the end of the heat processing period, the difference in concentration between top and bottom of the jar was less than 6% (unpublished data). Because product-induced stratification was less extensive than in the other products, the heating rate was not affected by the presence of sucrose in the covering syrup.

TABLE 1

Heating rates, f_h, min, of some fresh cucumber pickle products

Product	Jar size (oz.)	Covering liquor	
		Syrup[1]	Brine
Liquor only	16	12	11
Small, whole	16	18	18
Spear	16	36	21
Spear	28	52	22
Slice	16	33	20
Slice	32	45	24

[1] 50% sucrose except for the small, whole pickles which was 36%.

The heating rates, f_h, of 1% and 5% bentonite suspensions in 16-oz jars are about 11 min and 48 min, respectively *(16)*. It can be assumed from these data that the heating in sweet cucumber products (spears and slices) has not reached a state of pure conduction. There is ample room for speculation as to what is really happening during the heating of syrup-packed products, such as these sweet fresh cucumber pickles. To exhibit a criterion for no convection between specified points is not to say that convection cannot take place between other points. But, as density differences increase due to product-induced stratification, convection will be inhibited as the net force producing convection currents decreases. One possibility is that convection currents, rather than traversing the whole jar as would be expected for a pure convection situation, are restricted to smaller portions of the jar, depending on relative densities.

SUMMARY

This paper presents a method of calculating a criterion of no convection in syrup-packed products and presents evidence to suggest how this criterion is related to the difficulty of heating syrup-packed products in which product-induced stratification has occurred.

Acknowledgment

The authors wish to express their appreciation to Dr. D. J. Montgomery, Physics Department, Michigan State University, for his advice and comments on the analytical section.

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2. Ball, C. O. Thermal Process Time for Canned Food. *Bull. 37*, National Research Council. (1923).
3. Bates, F. J. and Associates. Polarimetry, Saccharimetry and the Sugars. National Bureau of Standards *Circular C440*. (1942).
4. Bedford, C. L., and Robertson, W. F. The effect of various factors on the drained weight of canned red cherries. *Food Technol.*, **9**, 321 (1955).
5. Bigelow, W. D., Bohart, G. S., Richardson, A. C., and Ball, C. O. Heat penetration in processing canned foods. National Canners Association *Bulletin 16L*. (1920).

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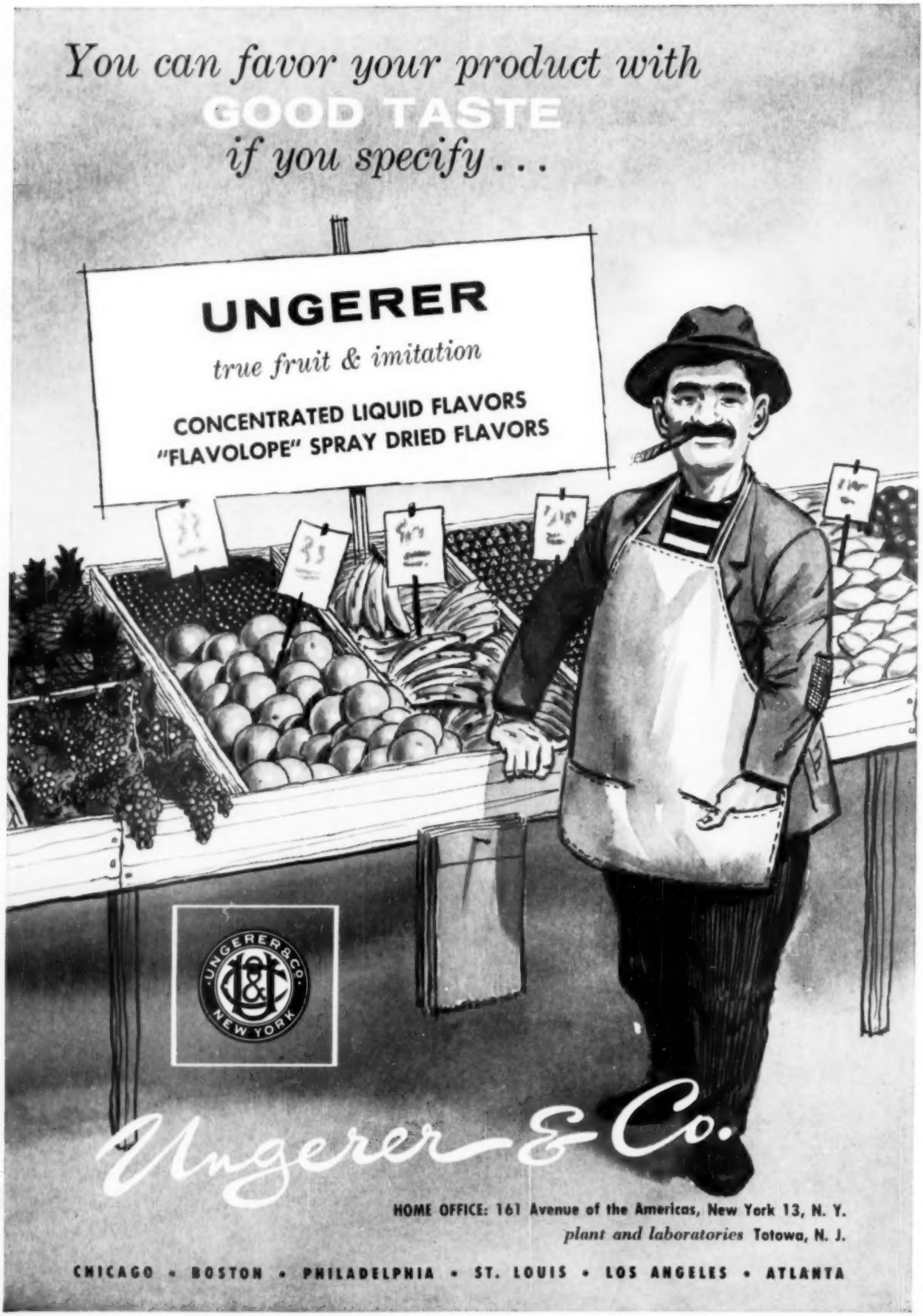

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Product-Induced Stratification of Covering Syrups[a, b, c]

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(Manuscript received May 21, 1959)

Product-induced stratification is the name given the concentration gradient of soluble solids which results when foods of high water and low solids content are placed in sugar syrup. When the syrup is first poured over the product, the concentration of solids in the syrup is uniform throughout the jar; when the product is marketed some months later, the soluble solids concentration of the syrup, although lower than it was initially, is again uniform. However, soon after the syrup is added to the product, a non-uniform gradient of soluble solids concentration is created because water leaving the product rises to the top of the jar, instead of diluting the surrounding syrup. Moreover, this non-uniform gradient is large enough to inhibit convection *(2)*, and continues to increase throughout the heating period.

This investigation is primarily concerned with a description of the dynamic processes which result in product-induced stratification in sweet fresh cucumber spears.

EXPERIMENTAL

Measurements. The following measurements were made: soluble solids concentrations in the syrup at the top and bottom of both heated and unheated jars of sweet, fresh cucumber spears at times ranging from 15 sec to 64 min after adding the syrup; soluble solids concentrations at 6 points (top to bottom) in heated and unheated jars of cucumber spears at 64 min and 24 hr after adding syrup; both product and syrup soluble solids concentrations at top and bottom of heated jars of cucumber spears at times from 1 hr to 213 days after adding syrup; acetic acid concentration in the syrup at the top and bottom of heated jars of cucumber spears at times from 64 min to 128 days; and pH in both syrup and product at top and bottom of heated jars of spears at times from 64 min to 8 days after adding syrup.

MATERIALS AND METHODS

The cucumbers used in this study were a slicing variety 1.5 to 2 in (3.8 to 5.1 cm) in diameter and 6 to 8 in (15 to 20 cm) long. A product known as cucumber spears was used in nearly all the work in this study; however, cucumber slices, cherries, and peaches were also tested for stratification. The details of the cucumber spear studies only will be reported here. The cucumber spears were prepared by cutting off the ends of whole cucumbers to obtain a nearly uniform cylindrical section 4.12 in (10.5 cm) long and then cutting this section lengthwise into 6 equal wedges. All the containers used in the tests were 16-oz glass jars (sometimes called 16-oz vegetable or No. 303 jars) with a lug finish. The spears were hand packed to a weight of 10.6 ± 0.2 oz (300 ± 5 g). Each spear was placed vertically in the jar, and the cut surface of the outer row of spears placed

[a] Journal Paper No. 2548, Michigan Agricultural Experiment Station, East Lansing, Michigan.

[b] Presented before the Nineteenth Annual Meeting of the Institute of Food Technologists, Philadelphia, May 19, 1959.

[c] This research is a portion of the thesis presented by T. R. Mulvaney for the M.S. degree, Michigan State University, 1958.

against the glass. The covering liquor was 50.0% sucrose and 2.8% acetic acid, by weight. The acetic acid had to be added to insure preservation because the heat process given the cucumber spears is adequate only for acid products. In most of the tests the jars were filled to the same distance below the top of the finish (0.5 cm) with 148 ± 15 ml of covering liquor. In the tests made to determine the vertical soluble solids concentration gradient and the tests made to determine the amount of stratification from 0.04 to 8 days, the volume of added syrup was fixed at 150 ± 2 ml. Both covering liquor and spears were initially at room temperature. Jars to be heat processed were immersed for 40 min in an agitated water bath maintained at 180° F (82° C) and cooled for 15 min in a water spray at about 54° F (12° C). Jars for the final equalization tests were stored at 74.0 ± 2.0° F (23.3 ± 1.1° C) in closed cases. The jars were handled carefully throughout the investigation to minimize agitation of the contents.

Hypodermic syringes and needles were used to remove 0.2 to 0.3 ml of syrup for each concentration measurement. Each pair of product soluble solids concentrations was measured at top and bottom in a single spear one end of which was at the top of the jar and the other at the bottom. Each spear taken was blotted to remove the surrounding syrup; a 0.5 cm section was cut from each end and pressed between the fingers to express the juice directly onto the refractometer prism.

The soluble solids concentrations were measured using a Bausch and Lomb Abbe 3L double scale refractometer, the sucrose scale of which is based on the International Sucrose Tables refractive indices at 20° C. The experimental data in this study are the refractive indices of the samples reported as per cent sucrose corrected to 20° C. It is recognized that these values include the contribution of the acetic acid to the refractive index.

The acetic acid concentrations, taken at the top and bottom of heated jars of cucumber spears, were determined by titration of 5.0 ml samples with 0.1N NaOH. The pH measurements of both syrup and product at the top and bottom of heated jars were made with a Beckman Model G pH meter equipped with "one-drop" electrodes. The liquid for the product pH measurements was obtained in the same way as that for the product soluble solids measurements.

RESULTS AND DISCUSSION

Figure 1 shows the rate of formation of the soluble solids gradient in both heated and unheated jars. These data are the averages of 4 unheated jars and 3 heated jars. It should be pointed out that each unheated jar can easily be sampled at more than one time during the test period. The same 4 jars were used throughout the unheated jar test, and, consequently, a total of 16 samples (total sample volume of about 4 ml) had been removed from each jar by the end of the test. In the heated jar tests, a jar could be used to supply only one pair of top and bottom samples. Each heated jar was removed from the bath at the stated time and the top and bottom samples taken quickly. Two people were required for this sampling; one took the top sample, the other the bottom. As a result, 24 heated jars were required for the whole test, 3 jars for each pair of top and bottom soluble solids concentration readings. A comparison of the soluble solids concentrations of heated jars with unheated jars (Figure 1) shows that more dilution of the syrup had taken place in the heated jars at the top and the bottom of the jar at any time after 8 min; however, the difference in concentration between top and bottom was about the same for heated jars as for unheated jars (see Table 1). The principal result to note is that the amount of stratification is not appreciably affected by the heating and cooling process.

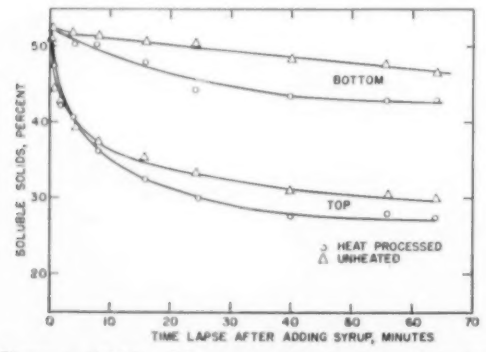

Figure 1. Soluble solids concentrations in the syrup in jars of sweet fresh cucumber spears.

TABLE 1

Differences in per cent soluble solids (bottom–top) in sweet, fresh cucumber spear covering liquor

Time, minutes after syrup addition	Heated	Unheated
4	9.9	12.3
16	15.6	15.6
64	15.8	17.8

The product-induced soluble solids concentration gradient was not constant throughout the jar. Figure 2 shows the soluble solids concentrations in the syrup measured at several points in heated and unheated jars at 64 min and 24 hr after adding syrup; each point is the average of two readings. The gradient in unheated jars, as a function of time and position in the jar, is primarily of academic interest; however, these unheated jar gradients are presented for contrast with the gradients in heated jars. Mulvaney *(1)* shows data for the gradient in unheated jars as a function of position at several times in the interval

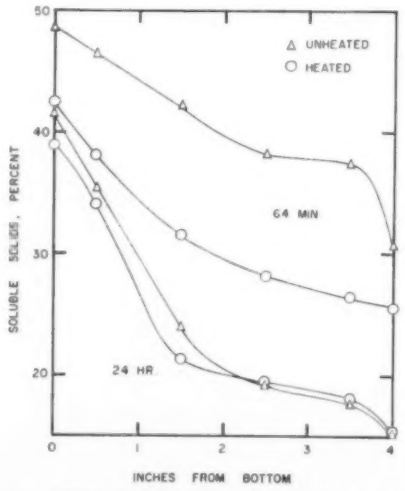

Figure 2. Soluble solids concentration gradients in the syrup in jars of sweet fresh cucumber spears.

from 1 to 64 min after adding syrup. The soluble solids concentration in the syrup in unheated jars at 4 min was nearly constant from the bottom of the jar to within half an inch from the top and dropped from 50% to 41% in the last half-inch; at 16 min the gradient had the same shape as it did at 64 min (see Figure 2), but the concentrations were higher at every point. Soluble solids measurements at 6 points during the heating period were not made because of the problems in obtaining samples.

Twenty-four hours after adding syrup, the gradient in the heated jars was about the same as that in the unheated jars, but there was a pronounced difference in gradients at 64 min (about 10 min after the end of the cooling period for the heated jars) even though the average gradient was about the same (see Table 1). The authors draw two tentative conclusions from the evidence presented in Figure 2: first, that the gradient is not constant at any time in heated jars; and, second, that the gradient in heated jars during the heating period cannot be deduced from the gradient at the corresponding time in the unheated jars.

A detailed knowledge of the gradient during the heating period is important. The slowest heating point is near the bottom of the jar and is a point of high sucrose concentration, and, therefore, a point of high lethality for many microorganisms associated with spoilage of fresh cucumber pickles *(3)*, primarily because of the high sucrose concentration. The top of the jar, which is the point lowest in sucrose concentration, is the point of highest temperature, and, therefore, a point of high lethality because of the temperature. The point of least lethality in a syrup-packed jar, formerly identified with the slowest heating point, will be that point at which the combined lethal effects of sucrose concentration and temperature give the least integrated lethality for the entire heating and cooling process.

Figure 3 shows the relationship between syrup and product at both the top and bottom of the jar for heat-processed sweet, fresh cucumber spears. These points are the averages of readings from three jars for each time; the first measurements were taken 64 min after adding syrup. Figure 1 shows the changes in soluble

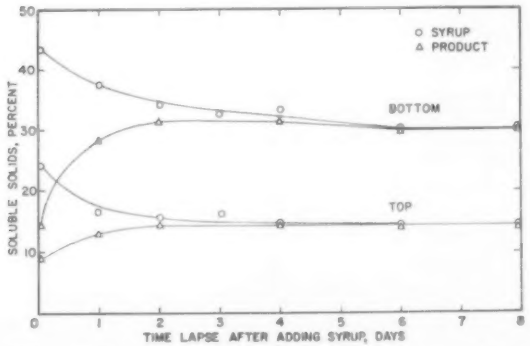

Figure 3. Soluble solids concentrations in heat processed sweet fresh cucumber spears.

solids concentration in the syrup only for the first 70 min; no data are available to show the changes in the soluble solids concentration in the product during this interval. The maximum top-bottom difference in soluble solids concentration occurred in the syrup about 1 day after adding the syrup and amounted to about 21%; the corresponding maximum difference in the product occurred at about 2 days and amounted to about 17%. The difference between the product and its surrounding syrup is a maximum at the moment the syrup is added. A period of 6 to 8 days was required for the soluble solids in the product and its surrounding syrup to reach equilibrium; during this period water was still leaving the product at the bottom, rising to the top, and there diluting the syrup. The maximum dilution of the syrup at the top of the jar was reached at 6 to 8 days at which time the soluble solids concentration in the syrup was 15%. The maximum water loss by the product, which produces product shrinkage and consequent poor appearance, was at the bottom of the jar. In this test this maximum loss occurred about 3 days after adding syrup at which time the soluble solids concentration in the product reached 31%.

Figure 4 shows the entire range of product and syrup soluble solids concentrations from just after the heating and cooling period to the time of final equalization [4] 213 days later. The data are shown on a logarithmic scale for convenience; each plotted point is the average of readings from 6 jars. At the end of 213 days the difference between soluble solids concentrations in the syrup at the top and bottom was 0.5%; the corresponding difference for the product was 0.1%. There was still a difference between product and syrup soluble solids of about 1%. The measured final equalization (average of top and bottom for both product and syrup) of 21.8% is in good agreement with the calculated final equalization of 22.3%, based on 148 ml of syrup (soluble solids concentration of 52.8%, specific gravity 1.24) and 300 g of cucumber spears (soluble solids 3.2%, specific gravity 1.00).

The facts presented in Figure 4 help to explain why these products are customarily held in storage for some time before being released for sale. This problem can be discussed by considering three phases of the final equalization of soluble solids concentrations between product and syrup throughout the jar. First is stratification, the movement of water leaving the product at the bottom of the jar and rising to the top because the density of the surrounding syrup is higher; stratification is the most rapid phase and reached a maximum in one to two days. Second is the equalization of the soluble solids in the product with that of the surrounding syrup; this phase of equalization takes longer than stratification and was reached in 6 to 8 days. Third is the final equalization between top and bottom soluble solids concentrations in product and syrup; this phase of final equalization

[4] The diffusion probably proceeds according to an exponential function, and, theoretically, would reach equalization at infinite time.

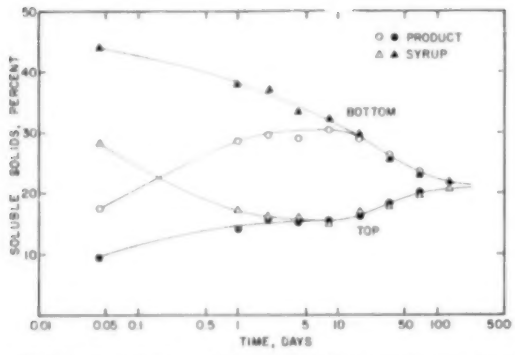

Figure 4. Soluble solids concentration equalization in heat processed sweet fresh cucumber spears.

takes the longest and required over 200 days in these experiments. Some processors of sweet, fresh cucumber products make a practice of inverting the finished jars after they are put in cases and before the cases are placed in the warehouse; that is, about an hour after adding syrup. If the jars are inverted at that time (see the first set of points in Figure 4) the product at the top will be at 18% soluble solids and the product at the bottom will be at 10%. If there were no mixing of the syrup, then the syrup would be the same; that is, 28% at the top and 44% at the bottom. If there were perfect mixing of the syrup, then the syrup concentration at the time of inverting would be about 30% (see Figure 2). Even in the case of perfect mixing restratification will take place because the solids content of the product at the bottom (formerly at the top) would still be less than the concentration in the surrounding syrup. It is a known fact that this practice does reduce the time required for final equalization, probably primarily because there is some mixing of the syrup and a resulting reduction in the high sucrose concentration at the bottom of the jar. The authors hazard the opinion that the best time to invert the jars, with the object of reducing the time required for final equalization, is at about 1 week. This time is not critical; any time between 5 days and 2 weeks should give similar results. At 8 days the maximum loss of water by the product at the bottom of the jar has taken place, and, therefore, maximum product shrinkage. If the jar were inverted at this time, the product having 15% soluble solids would be placed in syrup at 31% soluble solids, and the product at 30% (now at the top) would be placed in syrup at 15% (assuming no mixing of the syrup). If there were perfect mixing, the syrup would be at some value between 15% and 32%, perhaps 20%. The product now at the top should fill out by gaining water at the much faster rate of the second phase of equalization, equalization between product and surrounding syrup which should take place in 6 to 8 days. There would be some further stratification because soluble solids leaving the product at the top would be in a lower density region and should fall toward the bottom of the jar. The exact details of final equalization, if the jars are inverted, will depend on the time at which the jar is inverted and the degree of mixing of the syrup.

Table 2 gives the pH in syrup and product at top and bottom of heated jars at several times from 64 min to 8 days after adding syrup; the data are averages of values from 3 jars. The largest pH difference found between top and bottom in both the syrup (difference in pH of 0.62) and product (difference in pH of 0.54) was at the first sampling time, 64 min. No pH measurements were made after the 8th day.

TABLE 2

pH changes in syrup and cucumber spears after heat processing

Time, days after adding syrup	pH			
	Syrup		Product	
	Top	Bottom	Top	Bottom
0.04	3.93	3.31	4.13	3.59
1	4.06	3.54	4.11	3.69
2	4.02	3.60	4.05	3.66
4	4.09	3.70	4.03	3.73
6	4.03	3.73	4.07	3.75
8	4.02	3.71	4.04	3.75

Table 3 gives the acetic acid concentration in the syrup, percentage acid by volume, at top and bottom of heated jars at several times from 64 min to 128 days after adding syrup; the data are averages of values taken from 3 jars. The maximum difference found in the acetic acid concentration in the syrup between the top and bottom of the jar was at the first sampling time. Equalization of acetic acid concentration between top and bottom occurred at about 64 days after processing. The data given in Table 3 were not taken from the same jars as the data in Table 2; however, the pH and acetic acid concentration should be comparable unless there is lot-to-lot variation.

A limited number of tests were made using cucumber slices, pitted sour cherries and sliced peaches. Suffice it to say that these products stratified and then equilibrated at about the same rate as shown for cucumber spears.

Evidence has been presented for the existence of stratification in syrup-packed products. There remain the questions of why does stratification occur and what should be done about it?

A possible explanation why the water molecules leaving the product do not all mix with the syrup is that the water molecules do not have sufficient energy

TABLE 3

Syrup acetic acid concentration in heated sweet, fresh cucumber spears

Time, days after adding syrup	Percentage acetic acid[1]	
	Top	Bottom
0.04	1.33	2.82
1	1.12	2.23
2	1.14	2.41
4	1.18	1.98
8	1.17	1.90
16	1.34	1.71
32	1.47	1.53
64	1.48	1.47
128	1.48	1.45

[1] By volume.

to break or add to existing hydrogen bonds of water molecules and sucrose molecules that tend to attract the sucrose molecules into a dense, viscous mass. The process of water molecules diffusing into the syrup and/or adding to these bonds occurs slowly. As a result of this slow rate of diffusion, the water rises to the surface buoyed up by the surrounding heavier syrup before it mixes into the syrup.

Since there is a region of high sucrose at the bottom of the jar, there will be some retardation of convection currents *(2)*. The jars could be agitated during the heating process; this practice would presumably improve the heat transfer characteristics and decrease process time requirements. However, any gain in process time must be offset against the increased cost of agitation; moreover, even if the jars were thoroughly agitated during the heating and cooling periods, the syrup in the jars would still stratify as soon as agitation is stopped because at that time the product and syrup soluble solids are not in equilibrium. After agitation is stopped, water leaving the product at the bottom of the jar would encounter a high density syrup and rise to the top of the jar.

SUMMARY

These results indicate conclusively that when a high-moisture food product is placed in a sugar solution, the water leaving the product does not diffuse uniformly into the syrup throughout the jar, but instead rises to the top thereby giving rise to a density gradient. This stratification begins as soon as the syrup is added to the product. In one test with a heat processed sweet, fresh cucumber spear product, two minutes after adding the syrup, a difference of over 9% was found between top and bottom soluble solids concentrations in the syrup. This top-bottom difference in soluble solids concentrations continued to increase up to about one day after adding syrup. The soluble solids concentrations in the product lagged behind the concentrations in the syrup; appreciable differences persisted up to four days after adding syrup; equalization of soluble solids between the product and its surrounding syrup was reached at about eight days after adding the syrup, but final equalization throughout the jar was reached only after several months. Acetic acid concentrations and pH were also found to be different between top and bottom of the jars. There was no salt in the covering liquor used in these tests, but the authors think that salt would also stratify. It should be emphasized that stratification takes place during heat processing. Comparisons between heated and unheated jars of cucumber spears show that although both the top and bottom soluble solids concentrations in heated jars are lower than those in unheated jars at corresponding times up to an hour after addition of the syrup, the differences, and, therefore, the average gradients are about the same. Stratification during the heating period should retard convection. Agitation of the jars is discussed as a means of eliminating stratification during the heating period and, thereby improving heat transfer, but agitation is not recommended without qualification.

Arguments are presented to suggest that there are ways to minimize the time required for final equalization of soluble solids between syrup and product throughout the jar.

The present study has shown that during heat processing of syrup-packed products the water leaving the product selectively dilutes the syrup (sugar and acid). Given this fact, the question of heat destruction of microorganisms in syrup packs should be reexamined to take account of the constantly changing sugar and acid conditions to which these microorganisms are exposed during processing. In some regions of the jar the sugar and acid conditions may be significantly lower than were anticipated when the heat process was designed.

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Convection Heating Studies of Water-Syrup Layered Systems[a, b]

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(Manuscript received May 21, 1959)

THE ANALYTICAL TREATMENT of convection heating is usually restricted to the case of a homogeneous fluid in which temperature is the only source of the density differences that cause convection currents. In a previous paper *(2)* the authors presented evidence for the existence of product-induced density gradients (stratification) in syrup-packed products. In these products density differences are caused by selective dilution of the added syrup. This phenomenon suggested the possibility that stratification of the syrup would inhibit convection. A first-approximation criterion for no convection was presented in a previous paper *(3)*. In the present study, convection heating in a model system was investigated to show what can happen to the heating characteristics of a liquid under conditions of restricted convection.

A reproducible model system that truly represents the behavior of a food product is not easily obtained. Foods undergo irreversible changes during heating and cannot be heated repeatedly with the same results. Any system that does not undergo irreversible changes can be measured, in principle, again and again with reproducible results, but the results are not directly comparable to a food product. This very general consideration must modify any conclusions based on model-system behavior about food-system behavior.

EXPERIMENTAL

The first of two studies conducted in an attempt to simulate conditions in jars of sweet, fresh cucumber pickles involved placing water and 50% sucrose syrup solutions in layers in 16-oz glass jars. The layers consisted of the following fractions of syrup by volume in the containers: 0 (all water), ¼, ½, ¾, and 1 (all syrup). There were 5 different arrangements in all. In the ¼, ½, and ¾ layered systems, the syrup was first measured into the jar then the rest of the jar was filled with water by pouring it carefully on the syrup to avoid appreciable mixing. The initial temperature of water and syrup was 77° C.

For the second study, about 350 g of plastic spears, made by cutting solid 2-in diameter, 4-in long phenolic rods lengthwise into 6 equal wedges, were put in the jars; these plastic wedges are about the size and shape of fresh cucumber spears. The jars were filled as before with the 5 layered arrangements of syrup and water. The total volume of syrup and water necessary to fill the jar was about 7 oz. The only resemblance of the system to an actual cucumber pack is that of the product shape.

Both the jars with and those without plastic spears were heated by submerging them in an agitated water bath maintained at 180° F. Copper-constantan thermocouples in plastic rods were inserted through a pressure fitting in the jar cap and temperatures were measured and recorded by a 12-point (1 min cycle) temperature recording potentiometer. The thermocouples were located along the central axis of the jars at 1.3, 3.8, 6.3, and 8.8 cm from the jar bottom; that is, in the center of each quarter of the jar. Only one thermocouple at a time was placed in any one jar. Temperature records were obtained at 4 points for each of the 5 layering configurations.

Time-temperature plots of the experimental data were made on semilogarithmic coordinate paper and the heating rate, f_h, and lag factor, j, as defined by Ball *(1)*, were determined.

RESULTS AND DISCUSSION

Figures 1 and 2 give the average lag factor and heating rate at the 4 positions in the 5 layered arrangements for the systems without plastic spears. Table 1 gives the results of an analysis of variance of these data. There is no obviously discernible pattern to the effect of the layers on the lag factor although the few values that are quite far from the over-all mean ($\bar{j} = 1.23$) are in the region just under the

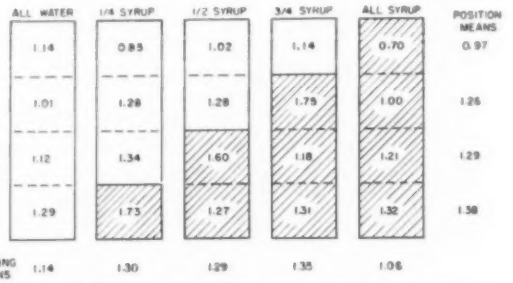

Figure 1. Average lag factors, j, in water-syrup (50% sucrose) model systems.

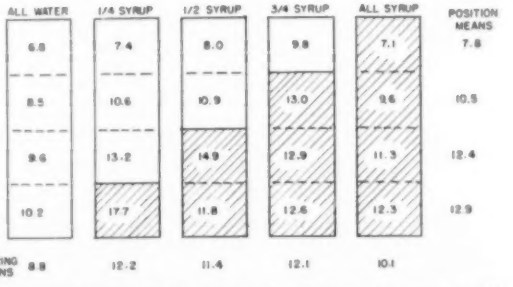

Figure 2. Average heating rates, f_h min, in water-syrup (50% sucrose) model systems.

[a] Journal Paper No. 2549, Michigan Agricultural Experiment Station, East Lansing, Michigan.

[b] Presented before the Nineteenth Annual Meeting of the Institute of Food Technologists, Philadelphia, Pennsylvania, May 19, 1959.

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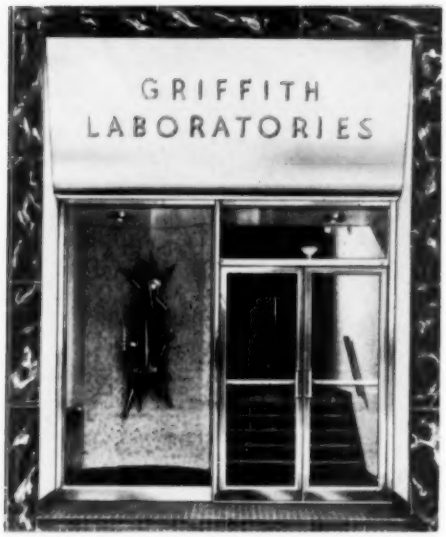

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TABLE 1
Analysis of variance of heating characteristics of model system

	Degrees of freedom	Lag factor, j	Heating rate, f_h
		Mean square	Mean square
Layerings	4	0.183	25.8*
Positions	3	0.482	80.1**
Interaction	12	0.144*	7.6**
Error	35	0.018	0.48

* Significant at the 5% level.
** Significant at the 1% level.

boundary between the water and syrup. The lag factor averages for all-water and all-syrup packs are lower than the averages for the other 3 configurations. These same general observations apply to the heating rate averages. The average heating rate for the all-syrup pack, f_h, (10.1 min) is just higher than that for all-water, 8.8 min, (not significantly different) and both are lower than the averages for the other 3 configurations (all-water is significantly different from the other 3 configurations). In the mixed layerings the slowest heating point (largest f_h) is in the region just under the boundary layer between the 2 liquids. The largest f_h appears in the configuration with ¼ syrup; the lag factor corresponding to this point is the second largest. It seems probable that convection takes place to some extent within each liquid layer, but there is no exchange of liquid across the boundary, except, of course, for a small amount being transferred by diffusion.

Figures 3 and 4 give the average heating characteristics for the model systems containing plastic

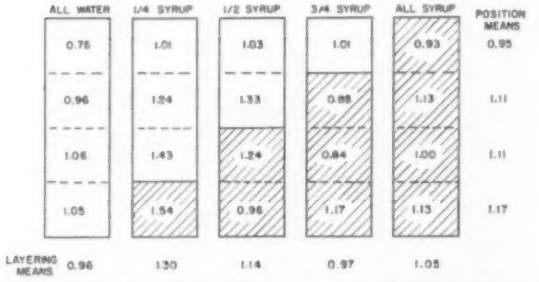

Figure 3. Average lag factors, j, in water-syrup (50% sucrose) model systems with plastic spears.

spears.[c] In these tests no effort was made to replicate all possible positions and all layerings so that the averages are calculated from 2 to 9 individual values. No statistical analysis was made of these latter results. The same general statements can be made about the location of the slowest heating points and the location of the largest lag factors. As before, all-water and all-syrup configurations heat, throughout the jar, faster than any of the other three configurations. For any particular configuration having two liquids the slowest heating point is in the region just below the boundary between the two liquids. The most striking difference between the systems with the plastic spears and the systems without them are the several extremely large f_h values. Why the presence of the spears should give rise to such slow rates of heating in some parts of the jars is not easily explained. The fact cannot be entirely explained by the increase in surface area that might be expected to retard liquid flow, because the all-water and all-syrup configurations with plastic spears heat just as fast, if not faster, as the same configurations without the spears.

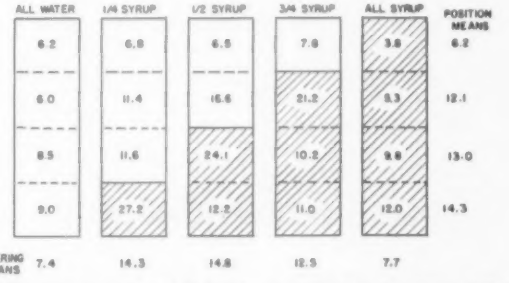

Figure 4. Average heating rates, f_h min, in water-syrup (50% sucrose) model systems with plastic spears.

SUMMARY AND CONCLUSIONS

Two model systems with built-in stratification that restricted convection to selected regions of a jar were examined to determine the effect of stratification on the heating characteristics throughout the jar. Heating rates, f_h, and lag factors, j, are presented for both model systems at four points in the 16-oz jars for each of five different layered arrangements.

When there were two liquids of different density in a jar the heating rates, f_h, were affected depending on the particular arrangement, the position in the jar, and whether the plastic spears were used. For example, in the layered system with plastic spears in which the layered arrangement was half-water and half-syrup, there existed large temperature differences in the syrup section that would normally lead to convection. Ten minutes after this jar had been in the 180° F water bath, a difference in temperature of 35° F existed between points only 2.5 cm apart; the colder point was above the warmer point, and this temperature inversion persisted throughout the heating period.

In general, the slowest heating points were found in the regions just under the boundary between the water and the syrup. Heating rates were more affected than lag factors. In both systems studied (with and without plastic spears) the all-water pack was the fastest heating (over-all jar average), but the all-syrup pack heated nearly as fast. The data suggest that the syrup alone is not responsible for the slow heating regions observed in some of the arrangements.

The resemblance of these model systems to food systems is remote, to be sure, for a number of obvious

[c] As a matter of interest, the heating rate at the slowest heating point in a jar of sweet, fresh cucumber pickles is about 40 min.

reasons, principal among them the fact that no liquid exchange takes place between "product" and covering liquor; the fact that the sucrose concentration gradient remains essentially constant throughout the heating period; and the fact that these concentration gradients are present at the beginning of heating and are larger than those found in food systems. Nevertheless, the authors believe that these results are suggestive of the changes in heating characteristics that are brought about by product-induced density gradients, and the density gradients produced by any external cause, such as the addition of dry sugar.

Acknowledgment

The authors wish to express their appreciation to Dr. W. D. Baten, Experiment Station Statistician, for his assistance in the statistical analysis.

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A Food Grinder-Recording Ammeter Method for Measuring Beef Tenderness[a]

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Florida Agricultural Experiment Station,[c] Gainesville, Florida

(Manuscript received October 29, 1959)

Consumer preference studies *(4, 9)* have indicated the importance of tenderness as an attribute of beef acceptability. Some question has arisen recently *(5, 7)* as to the reliability of Federal grades of beef and certain factors upon which grades are based, as indicators of tenderness. Use of an accurate objective measure of beef tenderness in the standards for grading carcass beef has some feasibility. However, since existing objective measures lack somewhat in reliability, simplicity, or convenience, a definite need exists for an improved technique of measuring beef tenderness. This technique should incorporate as many of the chewing processes as possible to approximate more closely the taste panel method of tenderness evaluation. The widely used Warner-Bratzler shear apparatus *(2, 3)* measures but one of the various forces involved in chewing; namely, shear force. Miyada and Tappel *(6)* were the first to report the use of a motorized food grinder for beef tenderness determination; Bockian *et al. (1)* compared tenderness evaluations using a similar apparatus to taste panel scores with promising results.

In this study two trials were conducted to compare tenderness evaluations of loin steaks and rib roasts obtained by a food grinder-recording ammeter device and the Warner-Bratzler shear technique to tenderness values determined by a taste panel of four judges.

[a] The Florida Agricultural Experiment Station Journal Series, No. 995.

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[c] Department of Animal Husbandry and Nutrition.

EXPERIMENTAL

Apparatus. The grinder apparatus (Figure 1) consisted of a household food grinder (Hamilton-Beach Model 1FG) wired in series with a strip-chart recording ammeter. A constant input of 120 volts ac was assured by the use of a voltmeter and a voltage transformer between the grinder and the power source. Total ampere seconds were determined by measuring the area

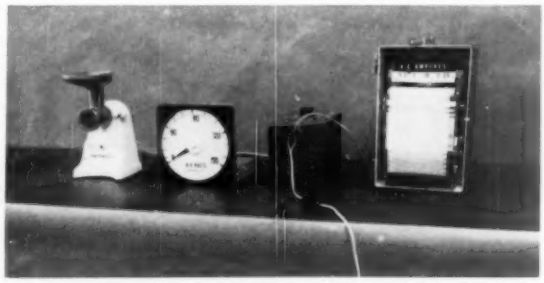

Figure 1. (From left to right) Hamilton-Beach food grinder, General Electric A. C. voltmeter, A. C. voltage transformer, General Electric recording A. C. ammeter.

under the ampere-time curves produced on the chart of the recording ammeter during grinding. The formula used for the calculation of E/g, or joules of energy per gram of sample was:

$$\frac{\text{Ampere seconds x volts}}{\text{Sample weight in grams}} = \text{E/g}.$$

The value E/g was used as the indication of sample tenderness.

Trial 1. Six adjacent 1-in steaks were removed from 81 short loins. The first pair of steaks were broiled and tested by both taste panel and Warner-Bratzler shear. The second pair were

broiled and tested by the food grinder. The third pair remained raw and were tested by grinder.

Steaks to be tested by shear had cores one-half inch in diameter removed from the top, center, and bottom sections of the *longissimus dorsi* for a total of 3 cores per steak. Each core was sheared twice, and individual shear force readings averaged.

After removal of the cores, the remainder of the *longissimus dorsi* was divided into 4 equal portions for testing by panel. Throughout the trial, each of the 4 judges tested portions from the same location within the steak. Tenderness was rated on a scale of 1 through 6, with 1 being the least tender and 6 the most tender.

Broiled steaks tested by grinder were trimmed to sections approximately one inch in width and extending the entire length of the loin eye. The sections were weighed to the nearest one-half gram and ground whole. After grinding the sample, the ground portion (that part forced through the face plate) was weighed in order to study the effect of weight of residue remaining in the grinder on calculation of E/g.

Raw steak samples tested by grinder were trimmed in the same manner as the broiled samples. Only the weights after grinding were used for the calculation of E/g, as the raw meat lost considerable weight from time of weighing to that of grinding due to evaporation and drip. Further, a larger percentage of raw meat remained in the grinder as a residue than was the case with the cooked meat.

Trial 2. Cooked samples of seventy standing rib roasts of the 6–7–8 rib cut were tested by panel, shear, and grinder. Tenderness evaluations obtained by these 3 methods on 34 of the cooked roasts were further compared with grinder values obtained on raw samples of the ninth rib section of corresponding roasts of the 9–10–11 rib cut. Only samples tested by grinder were replicated.

Three adjacent 1-in sections of the *longissimus dorsi* were removed from the 6–7–8 rib roasts; the first section was tested by grinder, the second by shear, and the third by panel. The sections to be tested by grinder (cooked and raw) were cut into two one-half inch thick sections to provide replicates. Grinder, panel, and shear evaluations were obtained in much the same manner as in Trial 1.

RESULTS AND DISCUSSION

Preliminary studies showed that when either cooked or raw samples were tested by grinder, a rather constant portion remained in the grinder as a residue which appeared only slightly altered physically and would thus have contributed little toward the total work (E) to grind the sample. Therefore, total work would be primarily a function of that portion of the sample forced through the face plate, and the most accurate calculation of E/g would be obtained using the weight of the ground portion rather than the weight of the sample prior to grinding. Since this effect would decrease as sample weight increased, the question arose as to whether the more readily obtainable pre-grinding sample weight would be sufficiently accurate for practical purposes, or whether the taking of a post-grinding weight would be necessary. Table 1 shows the effect of taking cooked sample weights before and after grinding on E/g in Trials 1 and 2. In Trial 1, where the mean sample weight prior to grinding was 50 g, no significant effect on E/g was found due to the 2 methods of weighing. In Trial 2, where the mean sample weight prior to grinding was only 30 g, the use of pre-grinding weights significantly affected E/g. Thus, it would appear that pre-grinding weights could be used without introduction of appreciable error if initial sample weight approached 50 g. However, with samples weighing around 30 g, post-grinding weights provide the more accurate basis for the calculation of E/g.

TABLE 1

The effect of taking cooked sample weights before and after grinding on E/g

Variables	Correlation coefficients	
	Trial 1—Steaks	Trial 2—Roasts
E/g and		
Sample 1 wt prior to grinding	.01	.36**
Sample 2 wt prior to grinding	.10	.26*
Sample 1 wt after grinding	.04	.08
Sample 2 wt after grinding	.10	.05

* Significant at .05 level.
** Significant at .01 level.

Estimates of repeatability of taste panel, Warner-Bratzler shear, and food grinder methods are presented in Table 2. The correlation coefficients between duplicate samples of the 3 methods point to the taste panel technique as being the most capable of duplicating performance in Trial 1, and the food grinder using raw samples as being the least repeatable. In Trial 2, only the grinder method was replicated. The repeatability of this method testing rib roasts appeared to be rather high and of near equal magnitude.

TABLE 2

Estimates of repeatability of panel, shear and grinder methods

Method	Number paired samples	Correlation coefficient between sample pairs
Trial 1		
Taste Panel (Broiled Steak)	81	.77**
Warner-Bratzler Shear (Broiled Steak)	81	.67**
Food Grinder (Broiled Steak)	81	.64**
Food Grinder (Raw Steak)	81	.45**
Trial 2		
Food Grinder (Cooked Rib Roast)	70	.69**
Food Grinder (Raw Rib Roast)	34	.67**

** Significant at .01 level.

The correlation coefficients used in Table 3 to compare the effectiveness of the Warner-Bratzler shear and food grinder methods to the taste panel method indicate the Warner-Bratzler shear method using cooked samples to be superior to the grinder method using either cooked or raw samples.

In Trial 1, the No. 1 duplicate of the Warner-Bratzler shear and food grinder methods were generally more closely related to taste panel than were the No. 2 duplicates. This effect may be the result of sample position in the loin. The literature *(8)* indicates some variation in tenderness from one end of the beef loin to the other. With such the case, samples farthest from those used by taste panel would be least likely to be related to tenderness of taste panel samples. Taste panel and Warner-Bratzler shear data were taken from the same steak in all observations—such technique providing maximum opportunity for a high correlation to be obtained. On the other hand, grinder samples were taken from sections of the loin at varying distances from taste panel samples, thus,

TABLE 3

Comparative effectiveness of Warner-Bratzler shear and food grinder methods of determining tenderness

Sources of variation	Correlation coefficients
Trial 1—Steaks	
Taste Panel Dupl. 1 (Broiled) and	
Warner-Bratzler Shear Dupl. 1 (Broiled)	−.73**
Warner-Bratzler Shear Dupl. 2 (Broiled)	−.53**
Food Grinder Dupl. 1 (Broiled)	−.60**
Food Grinder Dupl. 2 (Broiled)	−.27*
Taste Panel Dupl. 2 (Broiled) and	
Warner-Bratzler Shear Dupl. 1 (Broiled)	−.56**
Warner-Bratzler Shear Dupl. 2 (Broiled)	−.62**
Food Grinder Dupl. 1 (Broiled)	−.61**
Food Grinder Dupl. 2 (Broiled)	−.33**
Taste Panel Dupl. 1 (Broiled) and	
Food Grinder Dupl. 1 (Raw)	−.48**
Food Grinder Dupl. 2 (Raw)	−.26*
Taste Panel Dupl. 2 (Broiled) and	
Food Grinder Dupl. 1 (Raw)	−.39**
Food Grinder Dupl. 2 (Raw)	−.24*
Trial 2—Roasts	
Taste Panel (Cooked) and	
Warner-Bratzler Shear (Cooked)	−.79**
Food Grinder Dupl. 1 (Cooked)	−.47**
Food Grinder Dupl. 2 (Cooked)	−.47**
Food Grinder Dupl. 1 (Raw)	−.20
Food Grinder Dupl. 2 (Raw)	−.41*

* Significant at .05 level.
** Significant at .01 level.

allowing distance *per se* to minimize or reduce opportunity for high correlation.

In Trial 2, the relationship between taste panel and Warner-Bratzler shear was again higher than between taste panel and grinder methods. Since, in Trial 2, the duplicates for grinding came from the same sample and thus from the same position in the roast, the effect of position between duplicates is not seen. However, it might be noted that shear samples were located closer to taste panel samples than were the samples evaluated by grinder.

SUMMARY

Two trials were conducted comparing a motorized food grinder-recording ammeter apparatus and the Warner-Bratzler shear apparatus to a taste panel of four judges as methods of evaluating tenderness in beef. Tenderness values of the food grinder method were expressed as joules of energy consumed per gram of sample (E/g).

In Trial 1, the taste panel was found to be the most repeatable method, closely followed by the Warner-Bratzler shear and the food grinder using broiled samples. Testing raw samples, the food grinder was found to be the least repeatable method. Correlation coefficients showed a higher relationship between the taste panel and the Warner-Bratzler shear (−.73, −.53, −.56, −.62) than between taste panel and the food grinder methods (−.60, −.27, −.61, −.33). The food grinder method using broiled samples was more highly correlated to taste panel than was the food grinder using raw samples (−.48, −.26, −39, −.24).

In Trial 2, the food grinder using cooked samples of roasts and the food grinder using raw samples were both found to be rather high in repeatability. A higher correlation was found between taste panel and Warner-Bratzler shear (−.79) than between taste panel and food grinder (−.47) using cooked samples. The food grinder method using cooked samples compared more favorably to taste panel (−.47) than did the food grinder using raw samples (−.20, −.41).

Under the conditions of this investigation, the Warner-Bratzler shear apparatus appears to be a more precise measurement of tenderness than the food grinder.

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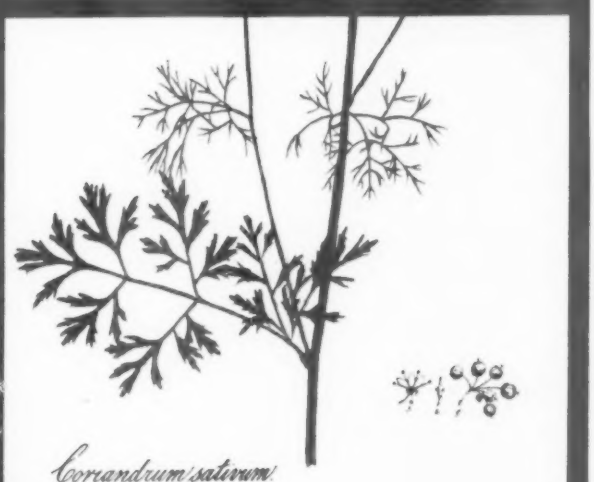

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Penetration of Tetracycline Antibiotics into Tuna, Sole, and Rockfish Flesh and Their Stability During Steaming and Retorting[a, b]

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(Manuscript received November 16, 1959)

STUDIES ON THE UPTAKE by or penetration into fish muscle of tetracycline antibiotics and on their heat stability therein have been carried out among others by investigators in Canada *(2, 3, 4, 11, 12, 13, 14)*, Great Britain *(10)*, India *(18)*, Japan *(15, 16, 17, 19)*, and the United States *(1, 8, 9)*. The fish used included freshwater species *(18)*, codling, flounder, haddock, bonito, mackerel, salmon, sardines and tuna *(4, 7, 8, 9, 10, 15, 16, 17, 19)* and gray cod, lingcod, halibut, sablefish and salmon *(2, 3, 11, 12, 13, 14)*, and shellfish *(1)*. The fish were stored in ice or refrigerated seawater containing the antibiotic, or were dipped in solutions of antibiotics and then kept under refrigerated but not freezing storage conditions. The concentrations of antibiotics, most commonly chlortetracycline, ranged from 1 to 50 ppm and the times of exposure to these concentrations varied from 5 minutes to 27 days. It was generally found that the skin and flesh immediately adjacent to it took up the greatest amount of antibiotic, with either none or only relatively small amounts of the order of 1 ppm detectable in the deeper layers of flesh below the skin. It was also reported that relatively short heating periods at temperatures approaching 100° C or 212° F or at the temperatures encountered during the usual fish preparative procedures produced a marked inactivation of the antibiotics in the fish. The heat stability data for tuna and tuna-like fishes were mostly carried out on fillets or pieces cut from whole fish. Steiner and Tarr *(12)* have reported that positive antibiotic assays have been found for untreated control fish; the least incidence of such "false positive" assays was found for lingcod.

Early in 1959 the U. S. Food and Drug Administration approved the use of chlortetracycline for treating whole or gutted fish, shucked scallops and unpeeled shrimp and set a tolerance of 5 ppm of chlortetracycline in these products *(6)*. This focused attention on the need for more available information on the penetration of the tetracycline antibiotics into certain Pacific Coast fish. In this class were the tunas, in the fishery of which the antibiotic could play an important part. In addition, data for fillets and other portions of fish would become important and useful when approval of the use of chlortetracycline was extended to cover all processed fish, such as fillets and steaks. Furthermore, it was also necessary to know the heat stability or lability of the tetracyclines during the various stages of the fish canning processes as well as during the modes of preparation of fish portions for home consumption. Work on the above problems was begun some years ago and data have been accumulated during the intervening time *(9)*. Although official approval of the use of chlortetracycline is limited in scope at present, it should nevertheless be useful to make the accumulated data available for study.

MATERIALS AND METHODS

Fish. The tuna used were frozen bluefin, skipjack, yellowfin and albacore which were thawed for use. The fillets were freshly cut from whole fish a few hours before experimentation began.

Immersion treatments. The thawed whole fish were immersed in 5 or 8% sodium chloride solutions with or without various concentrations of the antibiotic. The solutions were stored in a cold room at 30° to 35° F (−1.1° to 1.7° C). For determining the effect of skin on the penetration of antibiotic one side of a whole fish was skinned, exposing the flesh, leaving the skin on the opposite side intact. The fillets were immersed in various concentrations of chlortetracycline (CTC) in 5% sodium chloride solution. The usual immersion time was 5 min, except where the effect of time on the penetration was studied.

Determination of penetration and assays. For the whole fish an area of approximately 4 sq in was cut out from one side extending from the skin to about 3 inches in depth. The skin was removed, and then successive 1 cm layers were cut, using clean scalpels for each layer and taking care to avoid contamination between the various portions. Each layer was weighed and blended with 3 parts by weight of phosphate buffered solution of pH 4.5 to give a 1:4 initial dilution. Further dilutions were then made for the antibiotic assay, which was carried out according to a modification of the procedure of Grady and Williams *(7)*. The main features of the modification were the use of single layer agar (brain heart infusion, Difco), and of phosphate buffer pH 4.5 instead of the acetone HCl solution to extract the antibiotic. From the skinned side of a fish a section similar to that from the side with skin was cut out and an outer layer of flesh 0.5 cm thick was cut off, followed by two 1 cm layers of meat. The outer layer of flesh on the section from the skinned fish corresponded to, but was very much thicker than, the skin removed from the opposite side.

The entire contents of a can of tuna was separated from the oil and mixed well. A suitable aliquot was then weighed out and blended with 3 parts by weight of buffer solution of pH 4.5 for assay.

An entire fillet was taken for analysis, weighed, and blended with buffer as above. Three fillets were usually assayed for each determination and the triplicates were averaged.

[a] Presented in part at the 19th Annual Meeting of the Institute of Food Technologists, Philadelphia, Pa., May 17–21, 1959.

[b] Based on work carried out by P. Lerke in fulfillment of the requirements for the Ph.D. degree, University of California, June 1958.

Heat inactivation treatments. After removal from the immersion solutions the tuna were lightly rinsed with a fine spray of fresh water to remove any antibiotic solution adhering to the outside, sampled as described above, and then were eviscerated according to the usual commercial practice. The fish were then heated in flowing steam in a closed retort at 212° to 214° F (100° to 101.1° C) for increasing periods of time. After removal from the steam the fish were cooled at room temperature and sampled similarly to the raw fish. The fish were then cleaned and separated into loins, canned with a vegetable oil and sterilized by heating for 75 minutes at 240° F (115.5° C). The fillets were heat treated in 3 ways: steamed in free flowing steam for 5 and 10 min, baked in a preheated hot air oven at 350° F (176.6° C) for 15 and 30 min, and lightly fried for about 5 min to a golden brown color in hot oil in a frying pan. Two fillets were used per test and each test was run in triplicate.

RESULTS

The uptake of CTC and oxytetracycline (OTC) by whole tuna at 33° F (0.5° C) from solutions containing 18.4 and 17.6 ppm, respectively, is shown in Table 1. The average data from 3 experiments on the uptake of CTC from a 22.3 ppm CTC solution in 8% NaCl solution are shown in Table 2. The effect of concentration on the penetration of CTC into whole tuna immersed 7 days in a 5% NaCl solution is shown in Table 3. From these tables it is evident that the largest part of the antibiotic is retained in the skin and only relatively small amounts penetrate into the deeper layers of flesh.

TABLE 1

Uptake of tetracyclines by whole tuna from 8% salt solution at 33° F

Sample	Tetracycline-gamma/gram	
	Chlor-	Oxy-
Skin	3.28	7.7
1st cm flesh	0	0.19
2nd cm flesh	0	0

Fish immersed 7 days in av concentrations of 18.4 ppm CTC and 17.6 ppm OTC.

TABLE 2

Uptake of chlortetracycline by whole tuna immersed 7 days in 8% salt solution at 33° F

Sample	CTC as gamma/gram
Skin	4.4
1st cm flesh	0.10
2nd cm flesh	0

Average of 3 experiments with 22.3 ppm of CTC in the immersion solutions.

TABLE 3

Effect of concentration on uptake by whole tuna of chlortetracycline from 5% NaCl brine

Sample	Concentration of antibiotic-gamma/ml		
	8.3	100	470
Skin	3.2	56.0	340.0
1st cm flesh	0.34	3.9	48.0
2nd cm flesh	0	0	0.05

Immersion time was 7 days.

The effect of sodium chloride in the immersion solution on the penetration of CTC is seen from the data of Table 4. The uptake was similar under both conditions, with no apparent effect of the presence of NaCl.

The possible effect of breaks in the skin of whole tuna on the antibiotic penetration was next studied. Representative data from one experiment are given in Table 5. It can be seen

TABLE 4

Effect of NaCl on uptake of chlortetracycline by whole tuna after 7 day immersion

Sample	Solution	
	30 ppm in water	27.5 ppm in 8% NaCl
	Gamma/gram	Gamma/gram
Skin	5.1	4.9
1st cm flesh	0.18	0.15
2nd cm flesh	0.04	0

TABLE 5

Effect of skin on tetracycline uptake by whole tuna immersed in 8% salt solution at 33° F for 7 days

Distance from surface	Tetracycline-gamma per gram			
	CTC		OTC	
	+ skin	− skin	+ skin	− skin
1st 0.5 cm	3.3	10.0	7.7	12.4
Next 1 cm flesh	0	0.14	0.19	0.92
Next 1 cm flesh	0	0	0	0

The average concentrations of chlor- and oxy- tetracycline in the solutions were 18.4 and 17.6 ppm, respectively.

that the outside layers of the flesh act similarly to the skin as a barrier to the significant penetration of the antibiotics into the deeper layers of the meat. Outer layers of the exposed flesh took up somewhat more of the antibiotics than did the same layer of flesh with skin. More OTC was taken up by skin and outer layers of flesh than CTC and it also penetrated somewhat deeper than did CTC. Both antibiotics did not penetrate below the outer layers of flesh, and meat 1.5 cm below the surface gave negative assays for both antibiotics.

The destruction or inactivation of CTC in the flesh of tuna during steaming is shown by the data of Tables 6 and 7. From

TABLE 6

Stability of chlortetracycline in tuna during precooking in steam at atmospheric pressure

Sample	Gamma/gram after minutes in steam		
	45	90	180
Skin	1.1	0.28	0.04
1st cm flesh	0	0	0
2nd cm flesh	0	0	0

Average initial chlortetracycline concentration was 4.4 gamma per gram in the skin and 0.10 in the 1st cm of flesh.

Table 6 it can be seen that after 45 min exposure to steam 75% of the antibiotic which was originally present in the skin and 100% of that in the first cm of flesh was inactivated. After a 90 min exposure to steam 93.6% of the antibiotic originally in the skin was destroyed and 99.1% was inactivated after a 3 hr steaming. Presence of any antibiotic in the skin is of no importance or significance since the skin and some of the outer layers of flesh are discarded during the cleaning operation preparatory to the canning stage. Even after immersion in extremely high concentrations of CTC, resulting in the penetration of significant amounts of CTC into the skin, steaming for 1 hr inactivated 95.4 to 96.6% of the antibiotic originally present. No significant amounts of CTC were found in the flesh after steaming for 60 min even in the highest concentration. No antibiotic residues were found in any canned tuna, even after immersion in concentrations of 400–600 ppm.

The course of the uptake of CTC by sole fillets from various concentrations of CTC in 5% NaCl solution at ambient laboratory temperature is shown in Table 8. Penetration is fairly rapid up to 5 min, after which the rate tends to decrease, depending upon the concentration. Even after 1 hr in a 10 ppm CTC solution less than 5 ppm of CTC were found in

TABLE 7

Stability of chlortetracycline in tuna during steaming at atmospheric pressure

Hours in steam	Concentration of antibiotic in immersion solns.–ppm											
	8.3				100				470			
	0	1	2	3	0	1	2	3	0	1	2	3
Skin T/g	3.2	0.18	0.08	0	56.0	1.88	0.52	0.50	340.00	15.6	6.0	1.96
%	100	5.6	2.5	0	100	3.4	0.90	0.89	100	4.6	1.7	0.51
1st cm flesh T/g	0.34	0	0	0	3.9	0	0	0	48	0.06	0.02	0.002
%	100	0	0	0	100	0	0	0	100	0.12	0.14	0.004
2nd cm flesh T/g	0	0	0	0	0	0	0	0	0.05	0	0	0
%	....	0	0	0	....	0	0	0	100	0	0	0

the flesh of fillets. It may also be noted at this time that we have not found any false positive assays for CTC or OTC in any control untreated fish examined in this laboratory.

Two experiments were made attempting to simulate possible commercial dipping practices of repeatedly using a solution of CTC for dipping fillets. In Table 9 are shown data for 4 batches of fillets of 3 lb each being dipped for 5 min in the same 2 liters of solution at 2 hr intervals over a 6-hr total period. This is equivalent to a rate of 22.5 lb of fillets per gal of solution. In Table 10 data from a similar experiment are given, in which the treating rate was equivalent to 60 lb of fillets per gal of dipping solution. In both cases it is evident that there was some depletion of antibiotic from the solution, the amount depending upon the amount of fish used. There was also a decreased uptake of CTC by successive batches of fillets in the case of the larger lot, whereas no effect was found on the uptake with the smaller lot.

TABLE 8

Uptake of chlortetracycline by sole fillets from 5% NaCl solution at 23° C (73.4° F)

Concn. of CTC in solution ppm	CTC in fillets—ppm after minutes					
	1/60	2	5	15	30	60
0.76	0	0.047	0.145	0.29	0.57	0.46
3.7	0.052	0.22	0.87	0.81	1.08	1.80
10.0	0.12	1.22	1.74	2.54	3.44	4.20

TABLE 9

Uptake of chlortetracycline by sole fillets during continued use of immersing solutions over a 6 hour period

No. of treatment	CTC in soln ppm	CTC in fillets after treatment ppm
0	16.0	....
1	14.0	1.8
2	11.0	1.8
3	10.4	1.9
4	9.0	2.0

Three lb of fillets were immersed 5 min in the same 2 liters of 5% NaCl soln of CTC each time—12 lb of fillets were thus immersed in the 2 liters of CTC solution, equivalent to 22.5 lb per gallon.

TABLE 10

Uptake of chlortetracycline by sole fillets during continued use of immersing solution over a 6 hour period

No. of treatment	CTC in soln ppm	CTC in fillets after treatment ppm
0	14.5	.....
1	14.2	1.30
2	12.0	1.04
3	8.7	0.75
4	6.6	0.51

Four lb of fillets were soaked for 5 min in the same liter of solution each time—16 lb of fillets were thus immersed in the liter of 5% NaCl solution, equivalent to 60 lb per gallon.

TABLE 11

Uptake of chlortetracycline by fillets of rockfish during continued use of immersing solution over a 6 hour period

No. of treatment	CTC in soln ppm	CTC in fillets after treatment ppm
0	9.0	.....
1	8.5	0.39
2	6.8	0.39
3	6.2	0.33
4	5.9	0.32
5	4.9	0.22
6	4.5	0.22

Four lb of fillets were soaked for 5 min in the same liter of solution each time—24 lb of fillets were thus immersed in the 1 liter of 5% salt CTC solution, equivalent to 90 lb per gallon.

TABLE 12

Comparative uptake of CTC by sole and rockfish fillets after 5 minutes in a 4 ppm CTC soln in 5% NaCl

Fish sample	CTC in flesh—ppm	
	Individual fillets	Average
Sole	0.52, 0.56, 0.39, 0.56	0.508
Rockfish, entire fillets	0.32, 0.18, 0.39, 0.14	0.257
Rockfish, fillets sliced to approx. thickness of sole fillets	0.49, 0.56, 0.36, 0.56	0.494

Table 11 shows the uptake of CTC by rockfish fillets during repeated use of an immersing solution over a 6-hr period, with equal 72 min intervals between the first and second and succeeding batches of fillets. The CTC concentration in the dipping solution decreased with repeated use and the uptake of CTC by the fillets also tended to decrease in successive batches, although the decrease found was not progressive. This may reflect the effect of the conditions on the sampling rather than a real stepwise absorption of the antibiotic.

The effectiveness of CTC for the prolongation of the storage time of fish fillets has been reported many times. A summary of the literature has been given by Farber *(5)*. To illustrate the preservative action of CTC the results of a series of storage tests at 42° F (5.5° C) are shown in Figure 1. This is a plot of the increase in VRS content of batches 1, 4 and 6 of Table

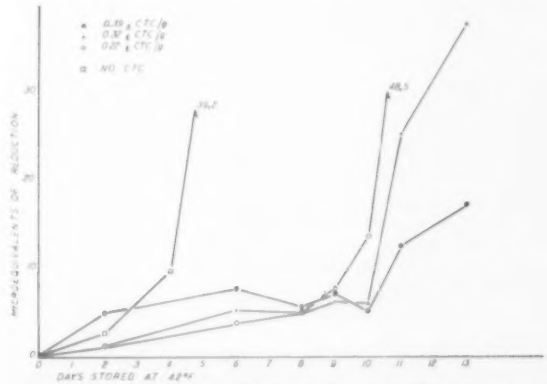

Figure 1. Showing the changes in the content of volatile reducing substances (VRS) of rockfish fillets containing various concentrations of chlortetracycline (CTC) during storage at 42° (5.5° C) (cf. Table 11).

TABLE 13

Stability of chlortetracycline in fillets of sole and of rockfish at 5° (41° F)

Fish	CTC gamma/gram—after days								
	1	2	3	4	5	6	7	8	9
Sole	1.78	1.84	2.22	1.88	1.51	1.34	1.49	1.70	1.36
Rockfish	1.55	1.50	1.42	1.16	1.10	1.39	1.00		

The values are averages of 4 experiments. The immersion solution contained 10 ppm CTC in 5% salt solution.

11 during storage until definite spoilage was evident. The fillets were considered unacceptable when a VRS value of about 15 microequivalents per 5 ml of press juice was reached. It can be seen that there was about a 2 day decrease in storage time between the first and last batches of the rockfish fillets immersed in the dipping solution. This was the result, probably, of the decreased concentration of CTC in the fillets, since the total aerobic bacterial count did not significantly change during the 6 hr of the experiment. A more detailed presentation of the effect of the repeated use of a CTC dipping bath on the effective storage period of fillets is planned in a subsequent paper.

On comparing the data of Tables 9 and 10 with those of Table 11 the apparently greater uptake of CTC by sole compared to that of rockfish fillets is evident. Since rockfish fillets are ordinarily much larger and thicker than sole fillets, the smaller surface exposed to the dipping solution by the former fillets compared to the latter could have influenced the amount of CTC taken up. To test this, sole and rockfish fillets, as received, were dipped in a 4 ppm CTC solution. The rockfish fillets were also sliced to a thickness approximating that of the sole fillets and then dipped. The results obtained are shown in Table 12. It can be seen that there is no significant difference between the CTC uptake by fillets of sole or rockfish of similar thickness.

The amounts of chlortetracycline remaining in sole and rockfish fillets during 9 and 7 days' storage at 41° F (5° C) are shown in Table 13. It is evident that the antibiotic is fairly stable under these conditions; 23.6 and 35.5% of the original amount of CTC had disappeared from the sole and rockfish fillets after 9 and 7 days, respectively.

Results of 3 types of heat treatment on the content of CTC in sole fillets are shown in Table 14. After a 5 min steaming 93.6% of the original CTC was lost and 100% after a 10 min steaming. In the free liquid which collected during the steaming there was found 0.16 and 0.06 gamma per gram, equivalent to 11.1 and 4.2% of the original amounts present. Baking at 350° F in a preheated oven inactivated 70.8% and 94.3% of the original amount of CTC after 15 and 30 min, respectively. A 5 min frying, the least destructive heat treatment, produced an 80.8% loss in CTC content. The inactivation of CTC during various heat treatments of rockfish fillets is shown in Table 15. In this case steaming for 5 and 10 min destroyed 76.8% and 98.7%; baking for 15 and 30 min 66.6 and 89.5%, and frying 100% of the original CTC present. However, the CTC content in the rockfish fillets after the various heat treatments was less than that in the sole fillets.

TABLE 14

Destruction of chlortetracycline during various heat treatments of sole fillets

Heat treatment	Concn of CTC in flesh-gamma/gram
None	1.40
Steamed 5 min	0.09
Steamed 10 min	0
Baked at 350° F	
15 min	0.41
30 min	0.08
Fried in hot oil 5 min	0.27

TABLE 15

Destruction of chlortetracycline during various heat treatments of rockfish fillets

Heat treatment	Concn of CTC in flesh of fillets-gamma/gram
None	0.39
Steamed 5 min	0.06, 0.09
Steamed 10 min	0.005
Baked at 350° F	
15 min	0.136, 0.124
30 min	0.04, 0.04
Fried in hot oil 5 min	0

DISCUSSION

From the data it can be seen that both the skin and the outer layers of flesh act as quite efficient barriers to the penetration of chlor- and oxytetracycline into the deeper layers of flesh. This resistance to the penetration of the tetracyclines into tissue has also been observed in living organisms, where high concentrations in the intestinal tract resulted in only very small concentrations in the blood and tissues of turkeys and pigeons. Furthermore, similar results were obtained with live fish in CTC solutions. Sticklebacks were placed in water containing an average of 56 ppm of CTC over a 120 hr period. At the end of this time the concentration of CTC in the intestinal tract of fish was 590 gamma per gram, in the body meat it was only 0.36 gamma per gram. This resistance to penetration can be looked upon as a safeguard against the presence of excessive amounts of antiobiotic in fish tissues in cases where higher than the recommended concentrations may be used. The fact that very little CTC and OTC penetrated into the deeper layers of flesh of tuna tended to facilitate the heat inactivation of the antibiotic during steaming, leaving practically none for inactivation during the heat sterilization stage of the canned product. No active antibiotic residues were found in any tuna canned from CTC- or OTC-treated fish. The same results were previously found for sardines, mackerel and salmon canned from antibiotic-treated fish.

During immersion of fillets of sole in antibiotic solutions there occurred a rather rapid uptake of the antibiotic within 5 min, and this was followed by a slower penetration up to an hour from solutions containing 10 ppm. CTC was found to be fairly stable at 41° F (5° C) in sole and rockfish fillets up to 7 to 9 days.

During three heat treatments simulating home preparative procedures, including steaming, baking and frying, there occurred a marked inactivation of the CTC originally present in the fillets. The Food and Drug Administration on April 16, 1959 stated that "A minute amount will remain in fresh seafood treated with the antibiotic and will not always be removed in cooking. FDA scientists and physicians

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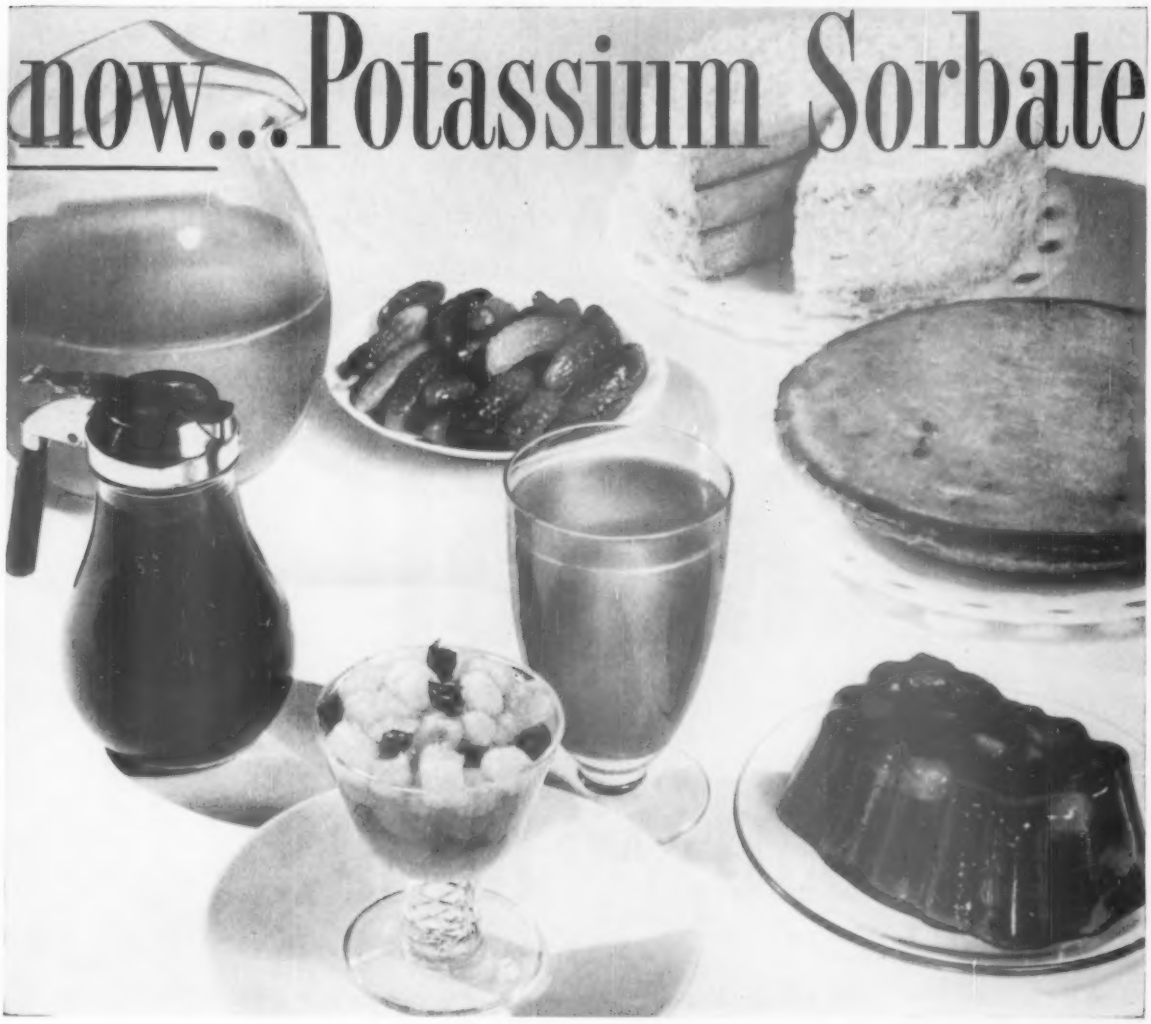

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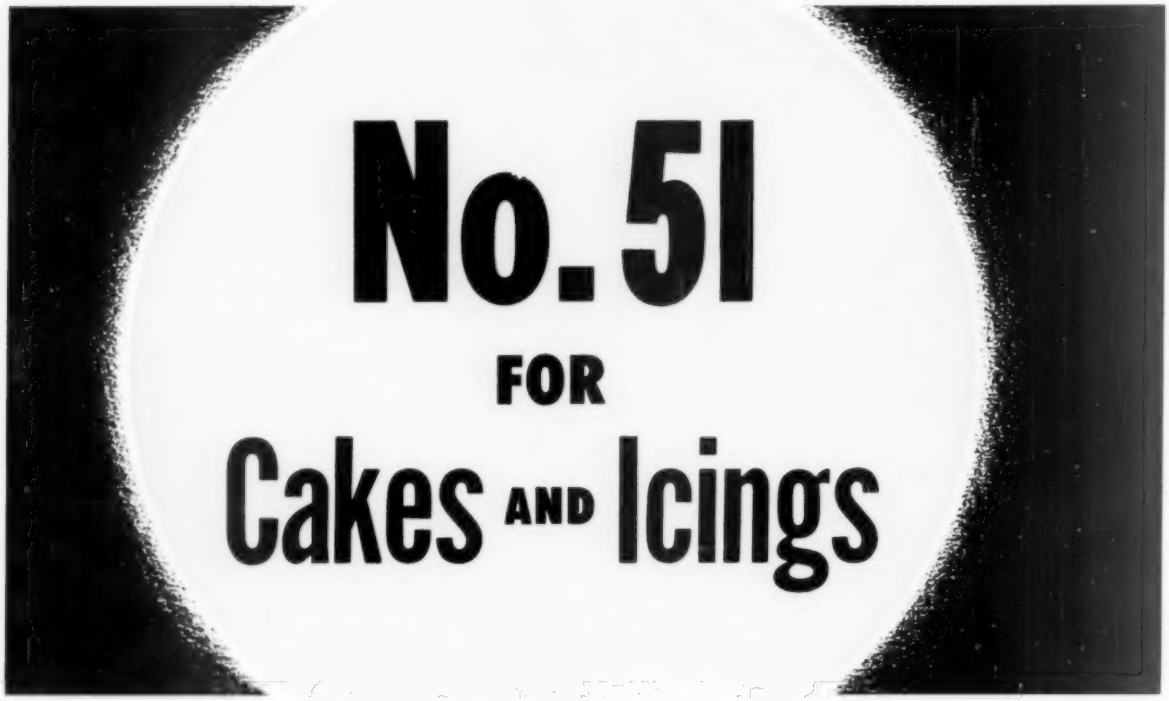

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have determined from all available data and feeding tests that this amount of chlortetracycline can be consumed without harm, even to the very few exceptional persons who may have developed a sensitivity to antibiotics." In the light of these statements, the very small amounts of active antibiotic residues, which may be sometimes found in heat-treated fillets, particularly baked or fried, can be regarded as of no significance from the public health point of view.

SUMMARY

The penetration into whole tuna and into fillets of sole and rockfish of chlortetracycline and of oxytetracycline into tuna was studied. No effect of NaCl on the penetration into tuna flesh of the antibiotics was found. The skin and outer layer of flesh acted as a quite efficient barrier to the penetration of the antibiotics into the deeper layers of the meat. This decreased penetration facilitated the subsequent destruction of active antibiotic during the steaming operation which is part of the tuna canning procedure. No active antibiotic residues were found in any cans of tuna packed from antibiotic-treated fish.

The uptake of chlortetracycline by sole fillets was quite rapid during the first 5 minutes of immersion, after which the rate tended to decrease up to an hour. The chlortetracycline in sole and rockfish fillets was quite stable up to 7 to 9 days storage at 41° F (5° C); the average losses during the storage periods were 16.8% and 16.5% respectively. The heat treatments of steaming, baking and frying, simulative of home preparative procedures, were found to markedly inactivate the active CTC originally present in the fillets of sole and rockfish. The actual amounts of antibiotic remaining after the various heat treatments were very small and could be considered as relatively insignificant, particularly in view of the statement by the Food and Drug Administration on April 16, 1959, relative to the safety of any antibiotic residues in cooked seafood.

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Pattern of Redness Loss and Regeneration in Prepackaged Beef[a, b]

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If meat could be prepackaged after slaughter and hanging and distributed to retail stores from a central point, the present practice of maintaining prepackaging facilities and operations in individual stores would be eliminated. This would also allow each store to be stocked with only those cuts for which it had the greatest demand rather than having to stock also other less popular cuts just because they are included in the large primal cuts which the store receives under the present system of distribution. This improvement in meat distribution would also aid the packer to meet the demand in individual areas for specific cuts and thus stimulate an over-all increase in meat sales. Because of these advantages and because of a concentration of packaging operations, the consumer, too, would benefit through a resultant reduction in cost of meat.

At the present time, meat is, for the most part, packaged in coated cellophane at atmospheric pressure. The film allows oxygen from the atmosphere to penetrate through to the meat while, at the same time, the coating retards the loss of moisture from the meat. The fact that oxygen can reach the meat from the atmosphere results in the temporary retention of a pleasing bright red color or "bloom" after packaging. Within 48 hours, this bloom is, however, replaced by a brown discoloration that is unacceptable to the consumer. The loss of redness which will occur during the time needed for transportation from a central point makes centralized prepackaging unacceptable and, in fact, prevents the packaging of meat at any other place than in the individual store.

How to overcome this problem of changed color has been the subject of much experimentation and discussion in the meat industry. Various persons have packaged meat experimentally in materials with differing permeabilities to moisture and oxygen and in atmospheres of inert gases or various partial pressures of oxygen. In some experiments, antioxidants and enzyme inhibitors have been employed. Although it was discovered that carbon monoxide will stabilize fresh meat color, avenues of approach to a solution of the color stabilization problem not involving the use of chemical additives have, in general, been unsuccessful.

In 1949, an investigation sponsored by the Bureau of Animal Industry was started by the Departments of Animal Husbandry and Food Science of Rutgers University to find a technic of prepackaging which would permit centralized prepackaging of fresh meat. The investigation was carried out along lines dictated by a different philosophy from that on which other investigators based their work. The project was concentrated on vacuum packaging, and air tight cans, sealed under high vacuum, were used as the control package.

It was found that fresh meat packed under vacuum lost its red color very quickly and that the higher the vacuum and the storage temperature, the higher the rate of color change. Surprisingly, however, in the light of published knowledge of the chemistry of meat pigments, as vacuum-packed meat in cans was held its red color returned. The rate of return was found to be influenced by several factors. Under the conditions of the experiments at the time of the discovery of the phenomenon of color return, it usually took 2 weeks or longer for an acceptable red color to return. The task of finding out how to accelerate the return of red color in cans was taken up and then to find a transparent film in which the action could be duplicated.

In the earliest work, cans were used in which only 20% or less of the volume of the cans was occupied by the sample. It was found that, since a perfect vacuum in the can could not be obtained, reducing the size of the can in comparison to the volume of the sample brought about an accelerated return of red color. The can was reduced to a size in which the sample occupied about 40% of the can volume. Later, a 211 x 011 can, in which the sample occupied at least 90% of the can volume, was employed and is being used in investigations at the present time. The findings of the early investigation were published serially in Food Technology under the title "Factors Affecting Quality of Prepackaged Meat."[c]

The recent investigation was sponsored by the Union Carbide Plastics Company (formerly the Bakelite Company) during a period of 3 years. This is the second published report on that work.

RESULTS OF STUDY OF MEAT DISCOLORATION[d]

Typical data are shown in Figures 1-7. These curves show redness of beef cuts after 36° F storage, measured by reflectance using a Gardner Color and Color Difference meter. An a_L reading above 12 is held to be acceptable red color, a value of 10–12 is questionable, and a value below 10 is not acceptable.

[a] Presented at the Nineteenth Annual Meeting of the Institute of Food Technologists, Philadelphia, Pa., May 19, 1959.

[b] A paper of the Journal Series, N. J. Agricultural Experiment Station, Rutgers—The State University, Department of Food Science, New Brunswick, N. J.

[c] Installments appeared in the following issues: Vol. XI, No. 5 (May, 1957), No. 7 (July, 1957), No. 10 (Oct., 1957), No. 11 (Nov., 1957), No. 12 (Dec., 1957), Vol. XII, No. 1 (Jan., 1958), No. 2 (Feb., 1958), No. 3 (Mar., 1958), No. 5 (May, 1958), No. 6 (June, 1958), No. 12 (Dec., 1958), and Vol. XIII, No. 3 (March, 1959).

[d] Earlier findings in this investigation were published in *J. Agr. Food Chem. (1)*.

Curves A, B, C, and D of Figure 1 are related to each other in that the same loin of choice beef was used as a source of meat for samples packaged in film pouches designated CIII (polyethylene-cellophane-polethylene) and in 211 x 011 cans both under vacuum and in air. The meat bloomed to what may

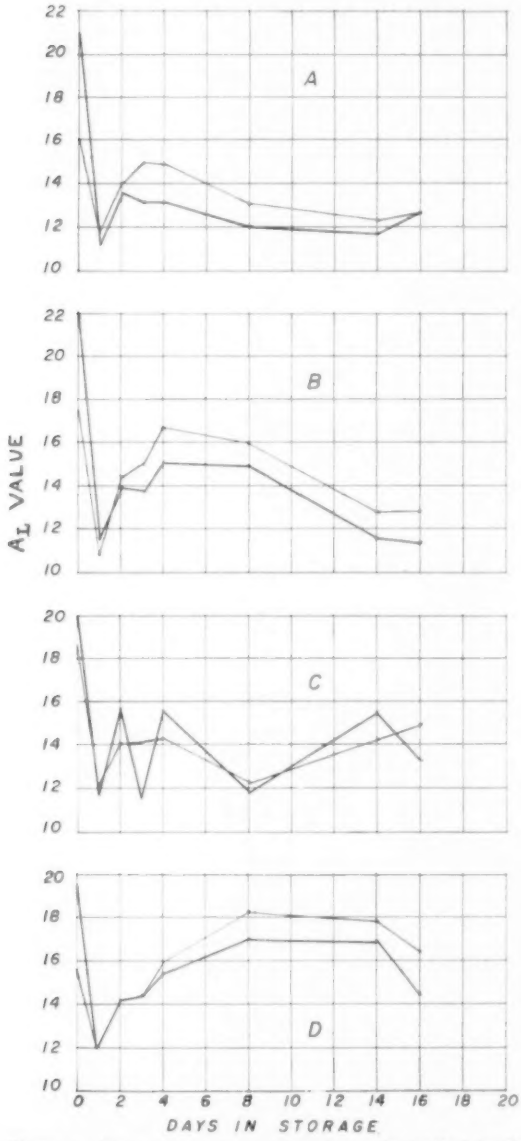

Figure 1. Mean redness value of beef samples packed in film pouches and in 211 x 011 cans both under vacuum and in air, Run M. A, polyethylene-cellophane-polyethylene in air; B, polyethylene-cellophane-polyethylene under vacuum; C, 211 x 011 cans in air; D, 211 x 011 cans under vacuum. The light line indicates bottom surface of samples; the heavy line, top surface of samples.

be considered an average or medium redness (a_L value) before packaging. This initial a_L value is shown at 0 days in storage.

The value of redness reached during the first day of storage was almost identical for cans and film packages whether packed under air or vacuum. After the low point in redness was reached, there occurred a return in redness on succeeding days in storage. The redness was stable except for samples packaged in cans in air, which, while they showed a return in redness on the second and fourth days of storage, showed lower redness of top surfaces on the third and eighth days of storage than the vacuum packaged samples.* Samples in film packages showed a poorer return in redness when packaged in an atmosphere of air than when packaged under vacuum.

The data indicate that, in either cans or pouches, it is better to package beef cuts under vacuum than in air.

Beef from a different animal, in Run O, also showed the results of packaging meat from the same loin in cans under both vacuum and air. The meat before packaging in this case also reached a medium redness. The first day's redness of samples for both air and vacuum packaging was almost the same. A loss had occurred. After this loss, there were sharp increases in redness on both the second and third days of

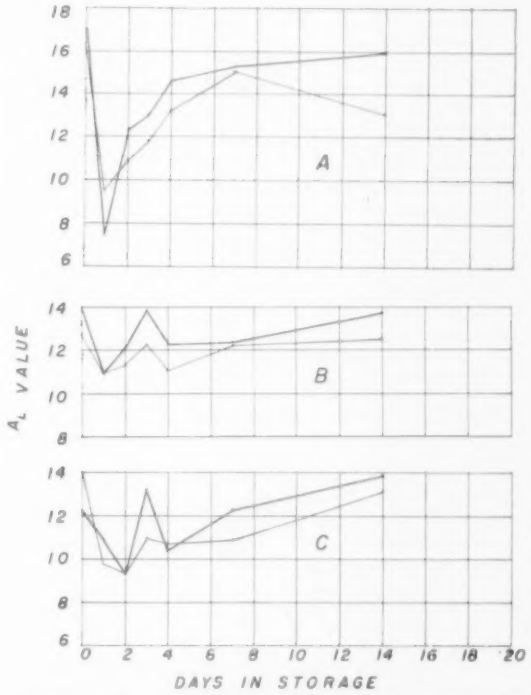

Figure 2. Mean redness value of beef samples vacuum packaged in 211 x 011 cans and in Mylar-Saran-polyethylene pouches, either coated on the inside with a glucose oxidase system or untreated, Run R. A, 211 x 011 cans; B, untreated Mylar-Saran-polyethylene; C, Mylar-Saran-polyethylene coated with glucose oxidase system. The light line indicates top surface of samples; the heavy line, bottom surface of samples.

storage and decreases on the fourth day. However, for air packaged samples, the decrease on the fourth day was much greater than in vacuum sealed cans. These results are not shown herein.

Comparing Curve C with Curve D, Figure 1, we have a strong indication that packaging beef cuts in 211 x 011 cans in air results in greater decrease in redness after 3 days' storage than results when beef cuts are packaged in cans under vacuum. A similar comparison involving meat from another source indicated a similar relationship between the vacuum- and air-packed samples but the color of both after 4 days was not as good in that meat as it was in the meat of Run M (Figure 1).

* For cans, as well as for foil or film pouches, the top surface is the surface which remains face up in the display case, while the bottom surface is that on which the sample rests.

The curves of Figure 2 also are related to each other by identity of meat source. Like the meat of Runs M and O, this meat (Run R) showed medium redness before packaging.

Samples vacuum packaged in 211 x 011 cans had an excellent pattern of redness return and subsequent redness stability. Samples vacuum packaged in untreated Mylar-Saran-polyethylene showed redness loss during the first day of storage, slight return on the second, and a sharp return for bottom surfaces and a slight return for top surfaces on the third day. There was a loss in redness on the fourth day of storage with later gains which were revealed in examinations at the seventh and fourteenth days of storage. Samples vacuum packaged in Mylar-Saran-polyethylene which had been coated with a glucose oxidase enzyme system according to U. S. patent 2,765,233 *(2)* showed loss of redness at 1 and 2 days' storage and a sharp return in redness of bottom surfaces with moderate return in top surface redness during the third day (Curve C). Subsequently, top surface redness remained relatively stable while bottom surface redness dropped sharply during the fourth day and increased moderately during the remainder of the storage period.

The enzyme was expected to decrease the amount of oxygen available in the package during storage and thus improve the red color pattern obtained. The enzyme treatment did not appear to have been either helpful or deleterious to color.

The curves of Figure 3 are related to each other because of meat source identity (Run Q). The meat in this case had low initial redness. All samples represented by these curves were vacuum sealed. This series provides a direct comparison between cans and 4 films. A comparison between pouches of two different sizes also was obtained (not shown in the graph).

Samples sealed in 5 x 6 in pouches of Mylar-Saran-polyethylene (Curve A) gave a pattern of redness similar to that given when this same film pouch was employed in Run R (Curve B, Figure 2), with a large increase in redness occurring during the third day of storage. Likewise samples packaged in 10 x 8 in pouches of the same material gave a pattern which is similar to that of samples in the smaller pouches except for redness in the former being lower on the second day of storage than on the first.

When samples were vacuum packaged in the usual 5 x 6 in pouches of polyethylene coated with polyvinyl alcohol (Curve B), they showed a strong return of red color of top surfaces as well as a moderate return of red color of bottom surfaces by the third day of storage. However, in Run Q there was a large loss in redness by top surfaces during the fourth day of storage. The redness at this point, nevertheless, was still near that of the samples at the time of packaging (0 days storage).

Samples packaged in 10 x 8 pouches of polyethylene coated with polyvinyl alcohol gave an excellent pattern of redness regeneration after discoloration occurred during the first day of storage. The redness of the top surfaces of meat in the 10 x 8 in pouches at 4 days' storage was greater than that at the beginning of the storage period. As with Mylar-Saran-polyethylene, however, the over-all pattern closely resembled that of the smaller pouch of the same material. This packaging film has been the most promising of those studied extensively in this investigation.

The "canned" samples (Curve C) showed quite a different pattern from the pattern of redness shown by other samples in cans (Curve D, Figure 1, and Curve A, Figure 2). The latter 2 samples in cans showed a large loss of redness by the first day of storage with at least a partial return in red color occurring by the second day of storage. Subsequently, this regeneration of redness was continued. The samples of Run Q, on the other hand, showed no loss of redness during the first day of storage, slight loss during the second day, and an increase in redness during the third day to a value above that of the initial redness. During the fourth day of storage there was again a drop in redness but thereafter there was not much change.

As indicated previously, the source of meat utilized in each of the 3 sets of cans mentioned in the previous paragraph was different. It seems reasonable to assume that a difference in the inherent characteristics of the meat used in Run Q (Curve C, Figure 3) from those of meat used in Runs M, and R (Curve D, Figure 1, and Curve A, Figure 2) accounts for the difference in pattern of color change. This difference seems to be associated with the low initial redness of the samples in Run Q, compared to that of the samples in the other runs. The bloom reached initially by the samples of Run Q was far less than is normally expected in freshly cut beef.

Samples packaged in 5 x 6 in pouches of polyethylene-cellophane-polyethylene (Curve D, Figure 3) likewise showed a large increase in redness during the third day of storage as well as a decrease in redness during the first and second days. Between the third and eighth days of storage these samples

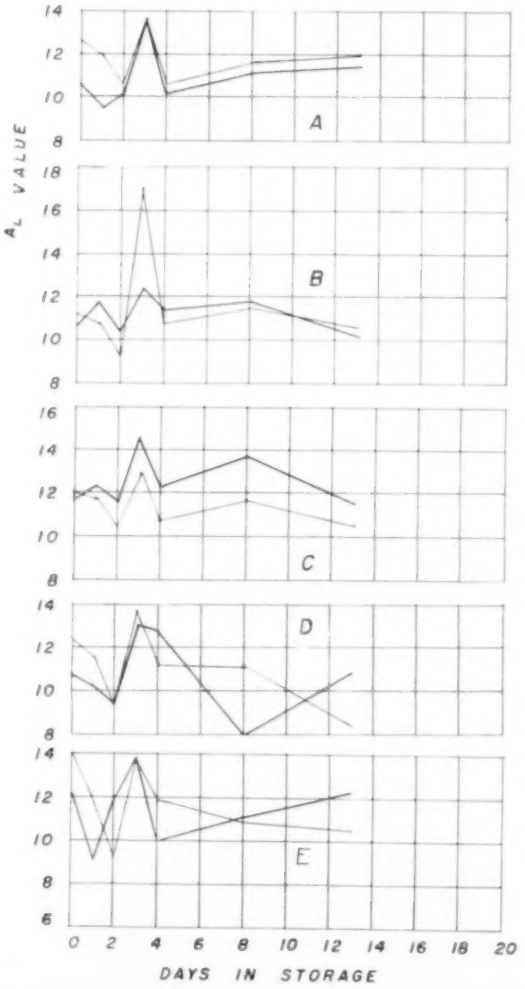

Figure 3. Mean redness value of beef samples vacuum packaged in 5 x 6 in pouches of four films and in 211 x 011 cans, Run Q. A, Mylar-Saran-polyethylene; B, polyethylene coated with polyvinyl alcohol; C, can; D, polyethylene-cellophane-polyethylene; E, Mylar-polyethyene. The lighter ine represents top surface of samples; the heavier line, bottom surface.

showed a large decrease in bottom surface redness. In samples of meat from the same animal, vacuum packaged in 10 x 8 in pouches of polyethylene-cellophane-polyethylene, a maximum redness was reached by the fourth day of storage. For these samples there was a slight increase in top surface redness during the first day of storage and a decrease during the second

day. The over-all pattern, however, as with the two laminates discussed above, closely resembled that of the 5 x 6 in pouch.

Samples vacuum packaged in 5 x 6 in Mylar-polyethylene pouches (Curve E, Figure 3) showed a large increase in redness during the third day of storage and a loss during the fourth day. This was similar to the pattern of the can in Curve C, and the Mylar-Saran-polyethylene pouch (Curve A).

The same piece of meat was used for all of the samples in Run N represented by Curves A, B, and C in Figure 4. This meat, before packaging, bloomed to a high intensity red color. All samples represented were vacuum packaged.

Samples packaged in Film C11 (polyethylene coated with polyvinyl alcohol) gave an excellent pattern of redness return at four days storage after a serious loss in bottom surface redness at 3 days' storage. Here, as in other instances, it may be said that this packaging film showed promise in the laboratory as a fresh meat prepackaging material.

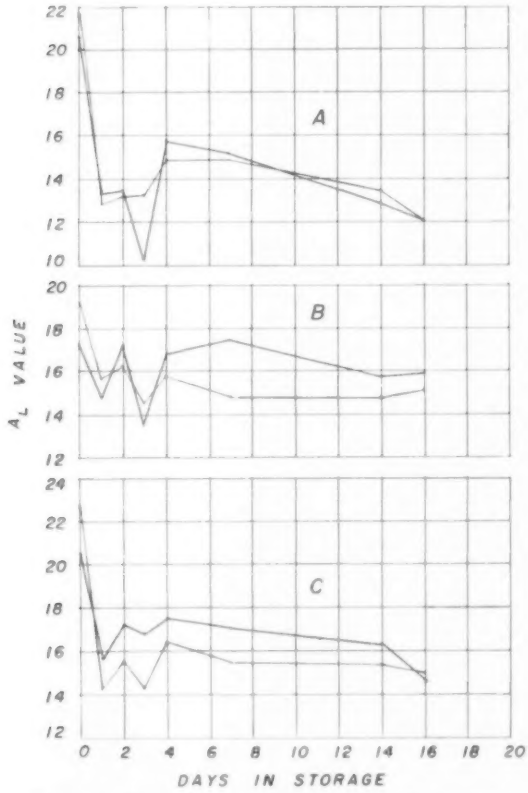

Figure 4. Mean redness value of beef samples vacuum packaged in two different films and in 211 x 011 cans, Run N. A, polyethylene coated with polyvinyl alcohol pouches; B, 211 x 011 cans; C, aluminum foil polyethylene pouches. The light line indicates top surface of samples; the heavy line, bottom surface.

The data presented in Curve B, Figure 3 and in Curve A, Figure 4 are typical of those obtained generally when beef samples were vacuum packaged in polyethylene coated with polyvinyl alcohol film. In all cases, after a storage period not exceeding 4 days, a good return in red color was achieved. In one of the instances shown, the maximum discoloration of the top surfaces occurred by the time the samples were in storage for one day, and a return in red color commenced during the second day of storage. In the other instance, the maximum discoloration occurred by the end of the second day. The intensity of redness of samples in both cases decreased at a low rate more or less progressively as storage continued after maximum redness return. Redness of the samples of Run N at 13 days' storage was slightly better than that of the samples of Run Q but redness of all samples was above the non-acceptable range at this point.

DISCUSSION

The reason for the moderate variations in redness pattern which occurred in meat vacuum packaged in the same packaging material in the same type of experiment is unknown. Variation in vacuum in individual film pouches and difference in size of film pouch may be responsible for some effects. It also seems reasonable to assume that these differences in pattern of color change could come from differences in inherent characteristics of meat.

Samples packaged in cans showed a serious loss of top and bottom redness at 3 days' storage but returned to high redness for bottom surfaces at four to 7 days' storage. In Run N (Curve B, Figure 4) top redness showed a slight return at 4 days' storage but another decrease between 4 and 7 days' storage. Cans, as we have shown previously (Curve D, Figure 1, Curve A, Figure 2), usually show a better redness pattern than this. It is notable in this case, however, that the redness of the samples in these cans never fell below an a_L value of 13, which is considerably better than a minimum acceptable rating for red color of beef.

Another example of difference in color history during storage which may be caused by differences in characteristics of beef from different animals is seen in Curve C, Figure 3, and Curve B, Figure 4. The samples were vacuum packaged in cans. The best over-all redness for the whole storage period was shown by samples (Curve B, Figure 4) which had a high redness before packaging (0 days in storage). The samples in the two cases were also quite different in respect to the times during storage at which maxima and minima of redness occurred. For the samples whose initial redness was low, a maximum of redness was shown at 3 days and minima at 2 and 4 days. The samples whose initial redness was high, showed maxima at 2 and 4 days and minima at 1 and 3 days' storage. Subsequent to the fourth day, redness in both sets of samples remained relatively stable.

Samples packaged in pouches of aluminum foil-polyethylene under vacuum (Curve C, Figure 4) showed good redness throughout the storage period and a fair pattern of redness return at 2 and 4 days' storage. It should be noted that with the exception of the color before packaging (0 days' storage) top surfaces of samples were inferior in redness to bottom surfaces throughout the storage period of 16 days.

A good example of the relationship between initial red color intensity and the subsequent pattern of redness change is shown if Curve D, Figure 1 and Curve C, Figure 3 are compared. These curves represent samples vacuum-sealed in cans. When initial top redness of samples was $a_L = 19$, after a loss of red color, a maximum return a_L value of 16.8 at 8

days' storage was reached. When the initial value for top surfaces was 11.9, there was redness loss at 2 days' storage, and, subsequently, the highest a_L value for redness reached was 12.9 at 3 days' storage. Similar results in respect to the relationship between initial and regenerated red color were obtained with samples vacuum packaged in pouches of polyethylene coated with polyvinyl alcohol (Curve A, Figure 4, and Curve B, Figure 3). Samples in this film with an initial a_L of 11.3 (curves not shown) showed a correspondingly low a_L return value for redness of 13.5 at four days storage for top surfaces. Other samples (Curve A, Figure 4) showed a high initial top redness value of 21.7 and a return value to 15.0 (high intensity for return redness) at the 4-day storage period. One series of samples (Curve B, Figure 3) had a low initial a_L value of 11.2 but a high 3-day storage value of 17.1 for top surface. However, the validity of this value as a measure of the redness of the meat at that stage is somewhat in question, since no readings above 12.5 were recorded for the remainder of the storage period.

It was hoped that an enzyme coating on the inside of pouches used to vacuum-package beef samples would decrease the amount of oxygen available in the package during storage and thus improve the red color pattern obtained, but the redness of samples so treated was not affected by the treatment (Figure 2).

The color which returns to vacuum-packaged beef is not a bloom red color, but rather a purple-red, although the purple is less prominent than in fresh beef immediately after cutting. The writers feel that this is an acceptable color for fresh beef. They also feel that the film materials tested and represented in Curve B, Figure 1, and Curves A and C, Figure 4, give a sufficiently rapid and large return in redness to make centralized prepackaging, provided mechanical packaging problems can be solved, a distinct possibility.

CONCLUSIONS ON RED COLOR OF VACUUM PACKAGED BEEF

From the data, the following general conclusions may be drawn:

1. With rare exceptions (Curves B, and C, Figure 3), beef cuts, vacuum-packaged in both cans and film packages, discolor on both top and bottom surfaces during the first day of storage.

2. Beef cuts vacuum packaged in materials of low permeability to air undergo a return in redness by the 2nd, 3rd, or 4th day of storage.

Samples in cans usually returned in redness by the second day of storage, although one set of samples in cans (Curve C, Figure 3) did not return until the third day of storage.

In some experiments, samples in the following film pouches showed regeneration of redness at 2 days' storage: polyethylene-cellophane-polyethylene, Mylar-Saran-polyethylene, polyethylene coated with polyvinyl alcohol, and aluminum foil-polyethylene. The last named film pouch might be regarded as a flexible can.

In other series, samples in polyethylene-cellophane-polyethylene, Mylar-Saran-polyethylene, polyethylene coated with polyvinyl alcohol, and Mylar-polyethylene showed an increase in redness by the third day of storage.

One series of samples in polyethylene coated with polyvinyl alcohol did not show substantial regeneration of redness until the fourth day of storage (Curve A, Figure 4).

3. After regeneration of redness occurs, red color of beef is relatively stable.

Although some sharp decreases or increases of redness may be noted at certain stages of storage, the trend after the fourth day during a storage period of fourteen days or more is toward either gradual increase or gradual decrease of redness.

Beef cuts which return in redness in 2 days after packaging appear to have greater stability of subsequent redness and less variation in redness during storage than beef cuts which return in redness in three days. As mentioned previously, most of the instances of return in 2 days have occurred with cans, although, under certain conditions, samples in several film materials also have given this pattern of redness return.

4. The three most successful materials among those used consistently in this investigation for vacuum prepackaging of fresh beef are small cans, aluminum-foil polyethylene, and polyethylene coated with polyvinyl alcohol.

An excellent pattern of redness can be achieved with these three packaging media. However, when identical meat was used for samples packaged in these three package types (See Figure 4), the samples in polyethylene coated with polyvinyl alcohol were the least stable in red color.

5. The maximum regenerated redness value achieved by beef cuts shows a strong correlation with the redness of the meat before packaging.

The redness of the meat has been thought to be controlled by the amount of red pigment present in the animal. This varies among animals. The authors believe, however, that the amount of "bloom" achieved by samples before packaging is affected by unknown factors which may be influential even though the amount of pigment present is high.

SUMMARY

The pattern of color change in storage of fresh beef samples from a given source is essentially the same for any given set of packaging conditions. Sometimes, the pattern is practically identical in beef cuts coming from different animals. There is considerable evidence, however, that the inherent characteristics which differ in meat from different animals may be responsible for substantial differences in color history during storage.

In containers that hold vacuum, the red color which appears in meat a few days after packaging is a durable color. The color of meat in vacuum tight containers is relatively stable for a period longer than the shelf life of the product. If mechanical problems in film packaging can be solved, it is apparent that

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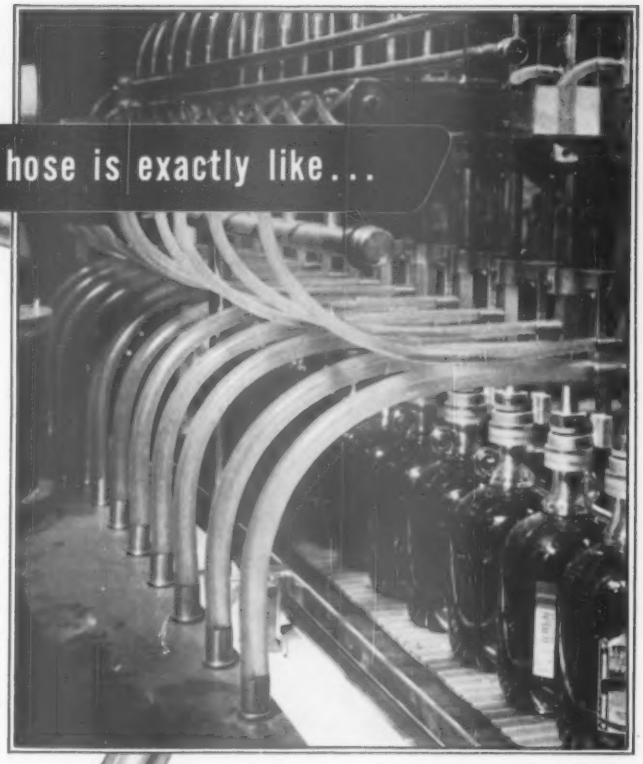

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meat can be vacuum packaged centrally and the meat industry will have entered a new era in distribution practice.

Acknowledgments

The authors wish to acknowledge the assistance of Dr. W. B. Ackart and Mr. R. Vaughn of the Union Carbide Plastics Company in the study of beef in 10 x 8 in film pouches reported here.

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Effect of Variety, Curing and Processing on Carbohydrate Content of Precooked Frozen Sweet Potatoes[a]

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(Manuscript received October 29, 1959)

The sweet potato, *Ipomoca batatas*, contains several chemical constituents, particularly carbohydrates, in sizable quantities that contribute greatly to its value as a food crop. The largest portion of the carbohydrate content of fresh sweet potatoes is starch; however, sucrose is found in sizable quantities along with some reducing sugar *(7, 8, 10)*.

When the sweet potato is subjected to heat treatments, a chemical change occurs resulting in a marked shift in certain carbohydrate components *(6, 7, 10)*. This change is represented primarily by a decrease in starch and an increase in maltose. Large amounts of beta amylase are found and it is reported that this enzyme is responsible for at least 60% of the starch breakdown that takes place during processing *(1, 9)*.

The degree of chemical change that occurs in the carbohydrate content of sweet potatoes depends to a large extent upon the kind and severity of the processing treatments to which the product is subjected. However, on a percentage basis, the chemical changes which occur naturally within the sweet potato during storage and processing treatments may not contribute to the final carbohydrate content nearly as much as the syrup in which the product may be cooked or preserved.

The processing techniques generally used in the preservation of sweet potatoes are canning and dehydration. Recently, however, preservation by freezing has become more common *(4, 5)*. This paper reports the results obtained in a study designed to determine the effects of variety, syrup concentrations and curing treatments on the carbohydrate content of sliced precooked frozen sweet potatoes.

[a] Approved by the Director of Research of the North Carolina Agricultural Experiment Station as Paper No. 1092 of the Journal Series.

MATERIALS AND METHODS

The treatment design was a 5 x 4 x 2 factorial arrangement with 3 replications and consisted of 5 varieties, 4 syrup concentrations, cured and uncured potatoes *(11)*. The varieties were Porto Rico, Goldrush, Georgia Red, Redgold and NC 171. One-half of the potatoes from each variety were cured for 7 days at 85° F and then stored at 55° F until processed. The other half (uncured) was placed in 55° F storage immediately after harvesting and held at this temperature until processed. None of the samples remained in 55° F storage longer than one week. The syrup in which the samples were cooked contained 0, 30, 45 and 60% sucrose, by weight.

The roots were peeled in boiling 10% lye for 7 min, rinsed, trimmed and cut into slices one-half inch thick. The slices were submerged in boiling syrup and cooked for 10 min after which they were allowed to drain for 5 min before packaging. The cooking time was the same for all syrup concentrations. The solution was boiled gently during the cooking process. Evaporation from the boiling syrup was compensated for by allowing enough water to trickle into the solution from a spigot mounted over the kettle to keep a constant syrup level. The cooked slices were packed in aluminum trays and frozen in an air blast at 0° F.

At the end of a 6 months' storage period the samples were thawed in a steam tunnel and mixed well with a Mixmaster. Total solids were obtained by drying 100 g of the mixed sample in a drying oven for 24 hr at 70° C. A 20 g aliquot of each mixed sample was taken and the sugar was extracted with 80% ethyl alcohol. The insoluble residue from the 20 g aliquot was dried for 24 hr at 70° F to determine the per cent alcohol insoluble solids (AIS). Sugars including sucrose and maltose were analyzed by the Schaffer-Somogyi method *(3, 12)*. Sucrose was hydrolyzed with invertase. Maltose was hydrolyzed by adding 2.5 ml concentrated HCl to 25 ml volume of sugar solution followed by heating the solution for 30 min at the

temperature of boiling water. Starch was determined by the Schaffer-Somogyi method after the alcohol insoluble solids were hydrolyzed with Taka-diastase and subsequent acid hydrolysis.

Weight losses that occurred during the cooking process were not determined for the samples from which carbohydrate analyses were made. Instead, the weight losses reported in this study represent a later experiment in which the samples were prepared and cooked in the same manner as those for which carbohydrate analyses were made.

RESULTS AND DISCUSSION

Total solids. Relatively little difference in total solids was found between samples from cured and uncured sweet potatoes after they were cooked in different syrup concentrations (Table 1).

As the sucrose concentration was increased in the cooking media there was a rapid increase in total solids until the syrup concentrations in which the potatoes were cooked reached 45% sucrose (Figure 1). The rate of increase in solids was not as great when the product was cooked in syrup containing more than 45% sucrose.

Wide variations in total solids were found among varieties (Table 3). The rate of increase in total solids as a result of higher syrup concentrations was very similar for all varieties.

Alcohol insoluble solids. On a percentage basis, little change was found in the alcohol insoluble solids (AIS) that could be attributed to syrup concentration (Figure 1). Alcohol insoluble solids were much higher in uncooked than cooked sweet potatoes. This difference was due for the most part to the breakdown of starch during the cooking treatments and a resulting increase in maltose.

Cooked samples from uncured stock possessed a significantly higher per cent alcohol insoluble solids than those from cured roots. This difference, however, was relatively small (Table 1).

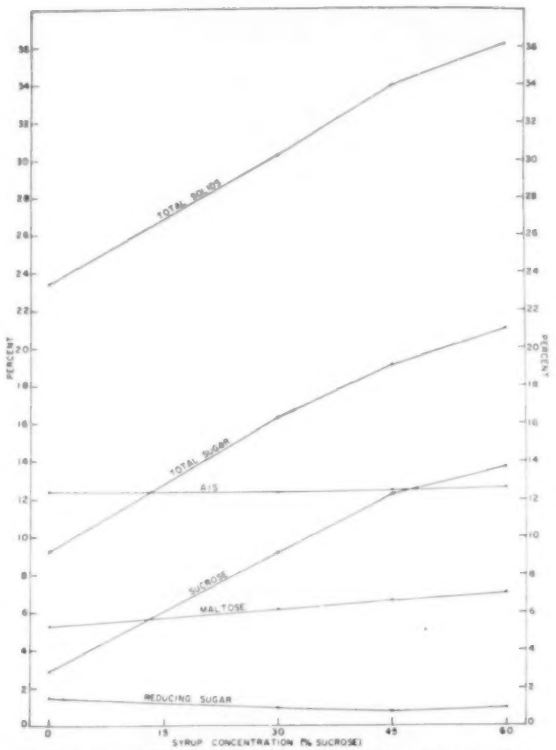

Figure 1. Average carbohydrate content in 5 varieties of pre-cooked, frozen sweet potatoes as affected by processing in different syrup concentrations.

Processed sweet potatoes of some varieties contained more alcohol insoluble solids than others (Table 3). All varieties responded very similarly, however, with respect to the alcohol insoluble solids content

TABLE 1

Effect of syrup concentration on per cent total solids, alcohol insoluble solids and starch of cured and uncured sliced, pre-cooked, frozen sweet potatoes (average of 5 varieties)

Treatment	% Total solids		Mean	% Alcohol insoluble solids		Mean	% Starch		Mean
	Uncured	Cured		Uncured	Cured		Uncured	Cured	
Raw—uncooked	24.1	24.6	24.3	18.6	17.0	17.8	14.0	12.7	13.3
Cooked in water	23.8	23.0	23.4	13.1	11.6	12.4	7.7	6.3	7.0
Cooked in 30% sucrose syrup	31.4	30.1	30.8	13.2	11.5	12.4	6.9	6.3	6.6
Cooked in 45% sucrose syrup	34.4	33.3	33.9	13.2	11.9	12.5	6.8	6.3	6.6
Cooked in 60% sucrose syrup	37.0	35.2	36.1	13.3	11.9	12.6	7.7	6.7	7.2
LSD at .05 level for:									
Syrup conc x curing treatment		0.4			0.3			0.3	
Syrup conc mean		0.3			0.2			0.2	

TABLE 2

Effect of syrup concentration on sugar content of cured and uncured sliced, precooked frozen sweet potatoes (average of 5 varieties)

Treatment	% Total sugar as dextrose		Mean	% Maltose		Mean	% Sucrose		Mean	% Reducing sugar		Mean
	Uncured	Cured		Uncured	Cured		Uncured	Cured		Uncured	Cured	
Raw—uncooked	3.4	5.4	4.4	0.0	0.0	0.0	2.5	3.9	3.2	0.71	1.28	0.99
Cooked in water	8.7	9.7	9.2	5.8	4.7	5.2	2.2	3.6	2.9	0.77	1.53	1.15
Cooked in 30% sucrose syrup	16.1	16.5	16.3	6.7	5.7	6.2	9.4	10.1	9.8	0.44	1.26	0.85
Cooked in 45% sucrose syrup	18.5	19.7	19.1	7.0	6.4	6.7	11.7	12.8	12.3	0.40	1.18	0.79
Cooked in 60% sucrose syrup	21.2	20.9	21.1	7.7	6.4	7.1	13.7	13.7	13.7	0.65	1.47	1.06
LSD at .05 level for:												
Syrup conc x curing treatment		0.4			0.3			0.4			0.16	
Syrup conc mean		0.3			0.2			0.3			0.11	

TABLE 3

Influence of syrup concentration on total solids, alcohol insoluble solids, and starch of five varieties of precooked, frozen sweet potatoes—expressed as per cent

Variety	Total solids Syrup concentration				Mean	Alcohol insoluble solids Syrup concentration				Mean	Starch Syrup concentration				Mean
	0%	30%	45%	60%		0%	30%	45%	60%		0%	30%	45%	60%	
Porto Rico	25.4	33.8	38.4	40.5	34.5	13.6	13.6	13.8	14.0	13.7	8.5	6.9	6.4	8.6	7.6
Goldrush	20.9	26.9	29.7	34.0	28.6	10.2	10.4	10.2	10.2	10.3	6.0	5.3	4.5	5.3	5.3
Georgia Red	24.2	30.8	34.6	36.2	31.4	12.6	12.8	12.6	13.1	12.7	6.8	5.9	6.5	7.5	6.7
Red Gold	22.6	29.4	33.3	33.9	29.8	12.0	12.2	11.9	11.7	12.0	6.5	5.7	6.8	6.6	6.4
NC 171	23.8	29.9	33.5	35.8	30.8	13.5	13.3	14.0	13.9	13.8	7.2	6.6	8.5	8.1	7.6
LSD at .05 level:															
Variety mean			0.3					0.2					0.2		
Var x syrup			0.6					0.5					0.5		

TABLE 4

Effect of variety and syrup concentration on the sugar content of pre-cooked, frozen sweet potatoes, expressed as per cent

Variety	Total sugar Syrup concentration				Mean	Maltose Syrup concentration				Mean	Sucrose Syrup concentration				Mean	Reducing sugar Syrup concentration				Mean
	0%	30%	45%	60%		0%	30%	45%	60%		0%	30%	45%	60%		0%	30%	45%	60%	
Porto Rico	10.3	17.6	22.2	24.0	18.5	6.6	7.9	8.5	9.1	8.2	3.1	9.9	14.3	15.6	10.7	0.73	0.31	0.26	0.40	0.43
Goldrush	8.7	17.1	17.3	21.1	16.1	4.3	5.3	5.6	6.1	5.3	2.6	8.0	11.0	14.1	8.9	1.94	1.44	1.36	1.64	1.60
Georgia Red	10.0	16.3	19.0	20.8	16.5	6.4	6.9	7.3	8.0	7.1	3.1	9.4	11.6	13.0	9.3	0.70	0.69	0.76	0.92	0.77
Red Gold	8.7	15.6	19.6	20.1	16.0	5.0	6.3	7.1	7.0	6.3	2.6	8.8	12.1	12.5	9.0	1.24	0.88	0.93	1.26	1.08
NC 171	8.3	14.9	17.3	19.2	14.9	4.0	4.6	5.0	5.2	4.7	3.3	9.7	12.3	13.5	9.7	1.13	0.99	0.64	1.09	0.96
LSD at .05 level:																				
Variety mean			0.3					0.3					0.3					0.13		
Var x syrup			0.6					0.5					0.6					0.27		

when cooked. That is, the varieties that contained the highest amount of alcohol insoluble solids in the raw state remained in that relative position when they were cooked in the different syrup concentrations.

Starch. Starch made up about 72% of the alcohol insoluble solids and slightly over 50% of the total solids in raw sweet potatoes (Table 1). In cooked samples the starch represented a much smaller percentage of the total solids. On a percentage basis, a considerable decline in starch occurred as a result of cooking. This loss of starch during the cooking process is accompanied by a buildup of maltose in almost the same magnitude. This is in line with the findings of other investigators *(2, 10)*. Little change occurred in the starch content during cooking that could be attributed directly to syrup concentration.

Curing treatments did not seem to greatly affect the starch content of precooked, frozen sweet potatoes. Starch was slightly higher in raw uncured roots than in the cured ones (Table 1).

Sugar. The per cent total sugar advanced rapidly as the sucrose in the cooking media was increased (Table 2). As may be noted in Figure 1, total sugar and sucrose increased almost parallel as the syrup concentration increased. The increase in total sugar was accounted for largely by the amount of sucrose present. There was a slight increase in maltose on a percentage basis as the syrup concentration advanced. This was accompanied by a decrease in the reducing sugar.

A relatively wide variation in the different sugar components existed among some varieties (Table 4). Sugar was highest in the Porto Rico and Georgia Red varieties. The amount of sugar in each of these two varieties was similar when the roots were cooked in low syrup concentrations. However, as the sucrose in the cooking media was increased, sugar in the Porto Rico variety advanced more rapidly.

Relatively little difference in the various sugar components was found between cured and uncured sweet potatoes except in reducing sugar (Table 2). In most instances there was more than twice as much reducing sugar in cooked and uncooked samples from cured roots as was found in uncured ones. However, in either case, the amount was so small that it contributed little to the total sugar content.

Maltose was not found in uncooked sweet potatoes. This is in agreement with the findings of other investigators *(2, 7, 10)*. Maltose was present, however, in all cooked samples.

Weight loss during cooking process. A graphic summary of the loss in weight that occurred in sliced sweet potatoes during the cooking process is shown in Figure 2.

The loss in weight progressed in a linear fashion, with increased syrup concentration, as indicated by correlation coefficients of 0.95 for Goldrush and 0.91 for NC 171 varieties. The linear correlation coefficient for samples produced from the Porto Rico variety was only 0.64. This relatively low correlation coefficient is probably due to the fact that the range of per cent weight loss was much smaller in the Porto Rico than that which occurred in the other varieties.

Weight losses that occurred during the cooking process were most likely due to a removal of liquid from the sample, thus resulting in a concentration of the solids. This factor may account for the apparent lack of decline in maltose and alcohol insoluble solids with the increased uptake of sucrose resulting from cooking in higher syrup concentrations (Figure 1).

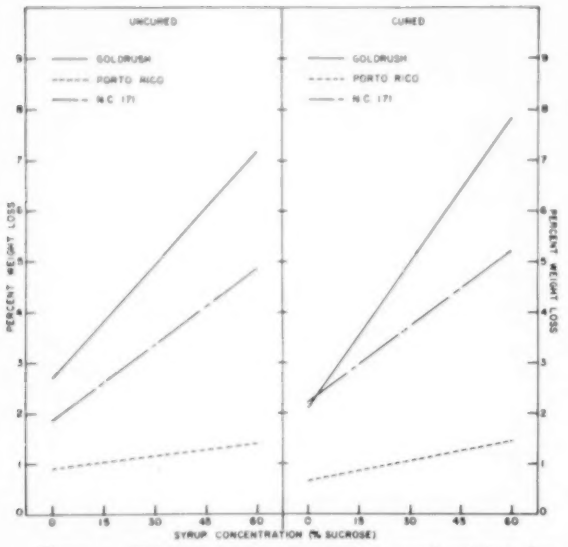

Figure 2. Weight losses that occurred in sweet potatoes during the cooking process.

Weight losses were not obtained for the samples for which chemical analyses were made. Instead, the phase of the study dealing with weight losses reported in this paper was carried out in a later experiment. It is believed, however, that they represent rather closely the losses that occurred in the samples for which chemical data are reported. If this be the case, it appears that a good correlation could be expected between the amount of loss in weight during the cooking process and the total solids content of the raw sweet potatoes. That is, those with higher solids would have a smaller per cent weight loss than the ones with a low solids content.

SUMMARY AND CONCLUSIONS

An investigation was made to study the effects of variety, syrup concentrations and curing treatments on the carbohydrate content of sliced precooked, frozen sweet potatoes. The sweet potato varieties included Porto Rico, Goldrush, NC 171, Redgold and Georgia Red. The roots were sliced and cooked in syrup solutions containing 0, 30, 45 and 60% sucrose, by weight. Cured and uncured sweet potatoes were processed.

The per cent total solids, total sugar and sucrose in the samples increased rapidly as the syrup concentration advanced from 0 to 60% sucrose. The average per cent total sugar increased from approximately 9% for samples cooked in water for 10 minutes to 21% for those cooked in a 60% sucrose solution. The apparent increase in per cent total sugar was accounted for almost entirely by an uptake of sucrose from the cooking media. On a percentage basis, there was a small increase in maltose and a decrease in reducing sugar as the syrup concentration advanced. There was little apparent change in per cent alcohol insoluble solids and starch that could be attributed to syrup concentration.

Wide variations in certain carbohydrate components existed among varieties. However, each variety responded similarly during the cooking process.

Little variation in carbohydrates was found in frozen sweet potatoes that could be attributed to curing treatments.

Weight losses occurred during the cooking process. In some instances it amounted to more than 7%. The higher the syrup concentration the greater the weight loss. Weight losses varied widely among varieties, with Porto Rico having the least and Goldrush the highest.

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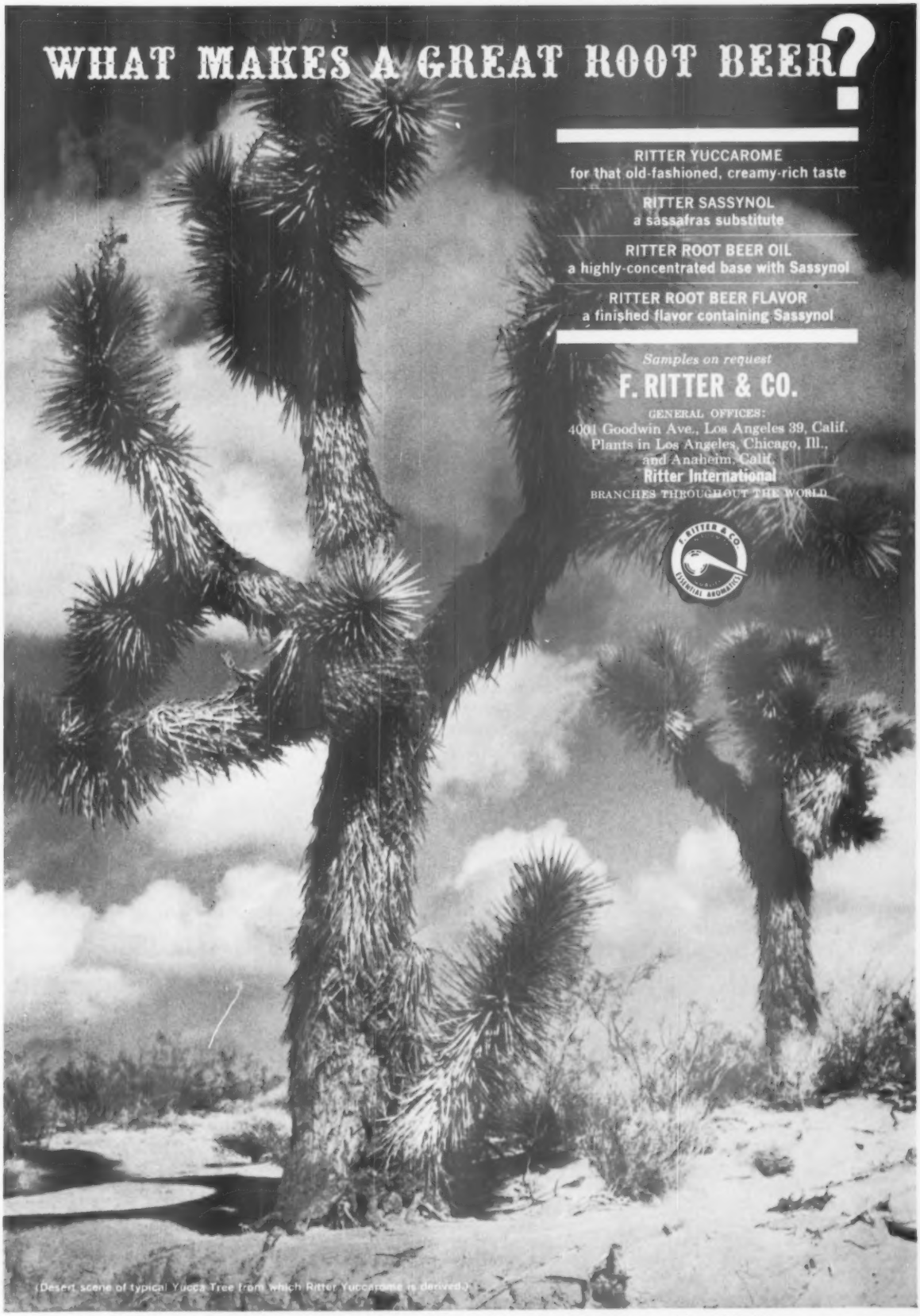

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Flavor Differences in Broths Prepared from Hormonized and Non-Hormonized Turkeys[a]

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(Manuscript received November 20, 1959)

WITHIN THE PAST FEW YEARS considerable interest has been aroused concerning flavor of poultry meat. Bouthilet *(1, 2, 3, 4)* and Pippen *(7, 8, 9, 10)* have studied flavor precursors in poultry meat. That hormonization has an effect on flavor of chickens as determined by taste panel comparisons of broth has been demonstrated by Fry *et al (5)*. In the latter research, however, the source of the difference between broths made from hormonized and non-hormonized birds could not be determined.

The present study concerned turkey meat and investigated the following possible sources of difference between broths:

1. Texture or mouth feel differences due to the presence of different amounts of fat.
2. Aroma differences in the fat itself.
3. Flavor differences in the broth.
4. Effect of cooking large amounts of fat with the broth.

These possible sources were studied in succession.

PROCEDURE

Seven turkeys were obtained from the Poultry Science Department of Purdue University. All birds were slaughtered at 17 weeks of age. Three of the birds had been injected at 10 weeks of age with 15 mg diethylstilbestrol diacetate, and one bird was injected at 10 weeks with 10 mg diethylstilbestrol. Both types of injection contained 3 mg methimazole and were incorporated into polyethylene glycol. The total injection into each bird was 0.226 cc. The remaining 3 birds were controls which had not been hormonized.

Broth was prepared from non-hormonized controls and hormonized birds according to the method of Pippen *(7)*. A third broth preparation was also made according to this method from lean meat of hormonized birds except that an amount of body fat equal to 20% of the weight of the meat was added. The fat and lean meat mixture was simmered 1½ hr in distilled water equal to one-half the weight of the meat alone. Distilled water was added after cooking to replace that lost by evaporation.

The broths were strained, placed in a separatory funnel, and separated from the fat. All batches of one type of broth were mixed and then frozen in glass jars and stored at −20.5° C. Fat from each type of broth was also mixed and frozen in small glass jars at −20.5° C. Broth and fat needed for one day were thawed each morning. Samples were prepared by homogenizing fat and broth together in varying proportions in a laboratory hand homogenizer. In all except one series of tests, fat was homogenized with the broth in which it was cooked. Temperature of the samples was maintained at 50° C by serving samples in test tubes kept in a water bath at that temperature.

Analytical judging was done in a separate taste room under green lights to prevent visual identification of the samples. The 8 judges were junior or senior students in Home Economics. During the training period judges were given samples with varying proportions of fat, broth and distilled water. Throughout the experiment judges were presented with triangle comparisons at timed 6-minute intervals. A total of 8 triangles were judged at one judging period. Judges were asked to pick the odd sample and to indicate which sample or samples contained the greater amount of turkey flavor. Samples were presented in randomized order within each day. Replications were made as necessary to obtain a large enough sample number for significant differences in a sequential testing plan according to the tables of Radkins *(11)*.

RESULTS AND DISCUSSION

It was confirmed during the training period that the judges could detect a difference among broth-fat homogenates made from hormonized, hormonized with added fat and control turkeys. These homogenates were prepared using the proportions of fat and broth present immediately after cooking. It was also found that judges could distinguish between fat levels of 1% and 2% or between 2% and 3% homogenized into turkey broth. Greater difficulty was experienced with higher levels of fat.

During the experimental period judges were unable to pick the odd sample of the triangle when 3% and 4% fat homogenized in broth in which it was cooked were compared (Table 1). This result would be expected on the basis of the logarithmic nature of response to sensory stimuli *(6)*. A larger difference between samples is required when the samples are more concentrated than when they are very dilute. The 3 and 4% levels of fat represent the approximate amount extracted during cooking from the control and hormonized lean meat used in preparation of the broth. The actual figures were 3.3% fat extracted in the control broth and 3.9% from the hormonized turkey broth. As the judges were unable to detect the slightly greater difference between 3% and 4% fat-broth homogenates, it is doubtful that a texture or mouth-feel difference plays a large role in the difference between hormonized and non-hormonized birds.

Additional evidence that the difference was not due to texture alone was obtained by comparison of the 3 broths with fat homogenized at the 3% level (Table 1). Even when there were no differences in the quantity of fat two of the three possible comparisons could be differentiated. No difference was detected between the control and the added fat-broth homogenates.

In order to test whether aroma differences in the fat as apart from texture caused the differences between hormonized and control birds, 3% fat of the 3 types used was homogenized into the control broth. No significant differences were found. This result indicated that the aroma contribution of the fat was not large enough to enable the judges to find a difference between samples.

[a] Journal Paper No. 1519 of the Purdue Agricultural Experiment Station.

[b] Associate Professor, Foods and Nutrition Department.

TABLE 1

Number of correct identifications of odd sample in triangle of turkey broth and fat homogenates

Samples compared	Trials conducted	Required no. correct for significance 0.95	Correct answers	No. of times sample selected
3% Fat[1] vs 4% Fat[1] in designated broth				
Control	62	31	26	
Hormonized	63	31	28	
Hormonized-added fat	24	16	10	
3% Fat[1] in designated broth				
Control vs Hormonized	63	31	40	Control 26 Hormonized 14
Control vs Hormonized with added fat	104	47	39	
Hormonized vs Hormonized with added fat	64	32	35	Hormonized 7 Hormonized-added fat 28
3% designated fat in control broth				
Control vs Hormonized	48	26	19	
Control vs Hormonized with added fat	32	19	6	
Hormonized vs Hormonized with added fat	48	26	13	
Broth only				
Control vs Hormonized	88	41	43	Control 28 Hormonized 15
Control vs Hormonized with added fat	72	35	46	Control 12 Hormonized-added fat 34
Hormonized vs Hormonized with added fat	40	22	25	Hormonized 6 Hormonized-added fat 19

[1] Fat homogenized into broth with which it was cooked.

The broth alone, without any fat homogenized with it, was then tasted. The judges were able to detect differences easily in all three possible combinations of samples. The broth appears to be the carrier of most of the flavor.

Hormonized birds may yield a less concentrated broth than does meat from non-hormonized birds because of their larger amount of intramuscular fat. The amount of muscle fiber in a weighed amount of the meat is decreased by the higher fat content and therefore makes a more dilute broth. It is possible that cooking the broth with a larger amount of fat alters the extraction of flavor from the meat. The flavor component does not appear to have dissolved in the larger amount of fat in added fat broth.

Choice of samples containing more turkey flavor is recorded in Table 1. The results include only those triangles in which the judge was able to identify correctly the odd sample. No trends were found in the series of samples comparing 3% and 4% fat in broth or in the series of 3% fats in the control broth.

In the two series in which trends were found, the comparative ratings of turkey flavor agreed. The judges most often rated the broth made from hormonized birds and added fat as containing the most turkey flavor. Broth made from control turkeys was rated second while broth from hormonized turkeys contained the least amount of flavor. The rating of samples in order of amounts of turkey flavor must be considered more subjective than the triangle comparisons for difference as the judges could not be given training in evaluating amounts of essential or characteristic flavor. That there was agreement in ranking the two series of samples indicates that judges were consistent in measuring the flavor component. However, this flavor may have been a generalized "meaty" extractive rather than the characteristic turkey flavor.

SUMMARY

Turkey broth was prepared from hormonized, hormonized with added fat, and control turkeys and presented to 8 judges as triangle comparisons.

Judges were unable to distinguish between 3% fat and 4% fat homogenized into the broth in which it was cooked or between 3% levels of the fat from different broths homogenized into control broth. Judges were able to distinguish between 3% levels of fat homogenized into the broth in which it was cooked and between samples of the broth alone. These results indicate that the difference between broth preparations of control and hormonized turkeys is not caused by texture or flavor differences in the fat but by differences in the broth itself. Judges rated the amount of turkey flavor of the broths in the following order: hormonized having the least amount of turkey flavor, control, and hormonized with added fat as the most flavorful.

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Influence of Blanching Conditions on Sloughing, Splitting, and Firmness of Canned Snap Beans[a, b]

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(Manuscript received November 12, 1959)

A QUALITY DEFECT found frequently in canned beans is a tendency for the skins to become loose and slough away from the main part of the pod. This leads to a downgrading of the product and serious economic loss. It has been suggested by Cruess *(1)* that blanching conditions might affect the occurrence of sloughing. McConnell *(3)* demonstrated that the tightest skins resulted from a 180° F blanch followed by a holding period. He showed also that calcium played a role in preventing sloughing.

Sloughing has been encountered by frozen snap bean processors as well as canners. Histological studies by Strohmaier *(5)* have shown that the separation of the skin of frozen beans resulted from a breakdown in the layer of large thin-walled parenchyma cells outside the vascular region of the pod.

Splitting is another undesirable phenomenon, particularly objectionable when beans are intended for institutional use. In the course of the present investigation it was noted that the ease with which the beans were split was also affected by experimental processing variations. Furthermore, the firmness of the beans was affected by the blanching conditions. On analysis of our data it appeared that the tendency of the beans to split, as well as their firmness, was closely related to sloughing. Data on these attributes are presented in this paper.

EXPERIMENTAL METHODS

The snap beans used in this study were grown during the 1958 season and were processed 1 to 3 days after harvesting. Except as noted, the data reported in this paper were obtained using the Tendergreen variety. The beans were cut into 1.5 in lengths and then size graded. Only size 4, the principal size grade processed in New York State, was used in this work. The beans were blanched in a small scale rotary type water blancher equipped with a variable speed drive and independent temperature controls on the feed and discharge ends. Following blanching they were cooled in water to 60° F. Canning was accomplished by placing 275 g of beans in No. 303 cans which were then filled with 2% sodium chloride solution at 200° F. After closing, the cans were cooked in a still retort for 20 min at 240° F and then cooled to 100° F and stored at 60–80° F.

The tendency of the skins of the canned beans to slough was estimated by their appearance and behavior when handled. The subjective judgments were replaced later by a test which measured the amount of material rubbed off the beans under controlled conditions. This test was made by placing 20 pieces of cut beans in a 300 ml Erlenmeyer flask together with 100 ml of distilled water. The flask was then stoppered and shaken on a Borel Wrist-Action Shaker at setting No 5 (350 shakes per min with an amplitude of 1.5 cm) for 5 min. The flasks were then removed from the shaker, swirled momentarily, and the liquid together with suspended solids poured into a 100 ml graduate cylinder. After 1 hr the level of the sediment in the cylinder was recorded. Results were expressed as ml of sediment. The amount of sediment was related to sloughing in that 0 to 6 ml of sediment indicated little or no sloughing, 6 to 12 ml corresponded to moderate sloughing, and over 12 ml of sediment were obtained from beans which showed severe sloughing.

The number of split pods resulting from the above procedure was counted and converted to per cent split pods. This figure was used as a measure of the tendency of the pods to split.

The firmness of the drained canned beans was determined with a texturometer in which the force required to move a 7 cm diameter piston to a level 3.8 cm from the bottom of a No. 303 can was measured with the aid of strain gauges and a recording potentiometer.

RESULTS

Effect of blanching conditions on sloughing. Sloughing increased as the blanch temperature was increased (Table 1). Skin sloughing occurred in varying degrees. In mild cases the principal loose tissue was the epidermal layer but when sloughing was severe considerable amounts of underlying tissue also separated from the pods. The increase in sediment volume with higher temperatures was also found with Kinghorn wax and white-seeded Cornelli 14 varieties although there were differences among varieties when compared with regard to a

TABLE 1

Effect of blanching times and temperatures on sloughing, splitting and firmness of tendergreen snap beans

Blanch temperature	Blanch time	Sediment	Split	Firmness
(° F)	(minutes)	(ml)	(%)	(lb)
150	2	2	0	236
160	2	2	0	242
170	1	2	0	243
170	2	1	0	250+*
170	3	2	0	250+*
170	4	1	0	250+*
180	1	1	0	210
180	2	1	5	184
180	3	2	10	190
180	4	4	5	178
190	1	11	5	144
190	2	12	35	108
190	3	14	30	104
190	4	14	20	111
200	2	17	60	97

* = Highest recordable reading.

[a] Presented at the Nineteenth Annual Meeting of the Institute of Food Technologists, Philadelphia, Pennsylvania, May 19, 1959.

[b] Journal Paper No. 1195, New York State Agricultural Experiment Station, Cornell University, Geneva, New York.

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particular blanching treatment. When no blanch was used the looseness of the skin depended on whether hot (200° F) or cold (70° F) brine was used to fill the cans. Cold brine filling led to higher sediment values than hot brine filling and both were much higher than when the beans had been blanched at 150° F. These results indicated that a heat treatment of some kind was needed prior to retorting in order to avoid looseness of the bean skins.

The length of blanch time also influenced the amount of sloughing, and was a significant factor at the higher blanch temperatures (Table 1). Even when the blanching time was reduced to one-half minute considerable sloughing was often present in beans blanched at 190° F.

The possibility that blanch temperatures over 210° F might yield satisfactory beans was investigated using a 1:1 mixture of glycerol and water as the blanching liquid. The results of this experiment (Table 2) showed that blanching at temperatures well over 210° F still led to severely sloughed beans.

TABLE 2

Effect of high blanching temperatures on sloughing of beans

Blanch liquid	Temperature	Time	Sediment	Split
	(° F)	(minutes)	(ml)	(%)
Glycerol-water[1]	221	2	36	100
Glycerol-water	212	2	29	80
Glycerol-water	176	2	9	0
Water	212	2	35	75
Water	176	2	15	20

[1] Glycerol-water solution made up of equal volumes of glycerol and water.

Use of successive blanches at different temperatures indicated that the skin-tightening process brought about by the lower temperature did not take place if the beans were first blanched at the higher temperatures (Table 3).

Effect of holding conditions on sloughing. The conditions of the holding period between blanching and retorting also influenced the occurrence of sloughing. This was particularly true if blanching was carried out at temperatures below 180° F (Table 4). Beans blanched for 2 min at 170° F, held 20 min, reblanched 2 min at 190° F, and held for 125 min before retorting gave a sediment value of 6 ml. Evidently a process which prevented sloughing was initiated by the 170° F blanch and was stopped by the second blanch at 190° F. This allowed us to study the effects of holding temperatures and times by subjecting the beans to a second blanch at 190° F to stop the toughening process whenever desired.

TABLE 3

The effect of a dual temperature blanch on the sloughing of beans

First blanch		Second blanch		Sediment	Split
Time	Temperature	Time	Temperature		
(minutes)	(° F)	(minutes)	(° F)	(ml)	(%)
2	170			1	0
2	170	2	190	5	0
2	190			18	30
2	190	2	170	17	40
½	190			11	0
½	190	2	170	5	0

TABLE 4

Effect of the holding time between blanching and retorting on sloughing of beans

Blanch temperature for 2 minutes	Holding time before retorting	Sediment
(° F)	(minutes)	(ml)
190	180	12
190	10	14
170	141	1
170	21	4

[1] Held at 80° F in air.

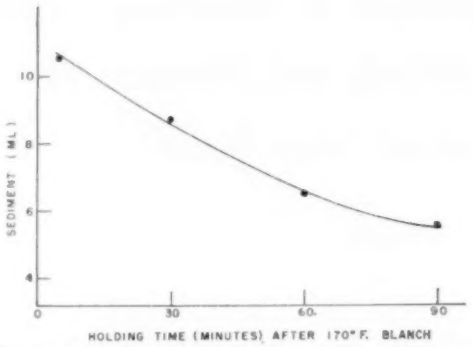

Figure 1. Sediment produced from canned beans held for various lengths of time at 80° F between an initial 170° F blanch and the final 190° F blanch.

By using such a procedure, a definite relation between sediment and holding time (Figure 1) and holding temperatures (Figure 2) was noted. The results obtained with the beans held at 170° F for an hour are particularly interesting. At the end of the holding time the beans had a cooked appearance and it was thought that they might yield an overcooked canned product. Nevertheless, they produced very little sediment in the sloughing test. In this connection further work has shown that a prolonged cooking of the beans in the retort (30 min at 240° F) had little effect on the looseness of the skins as compared to beans retorted under standard conditions.

Effect of calcium on sloughing. It has been pointed out by McConnell *(3)* that the use of an acidified calcium solution as

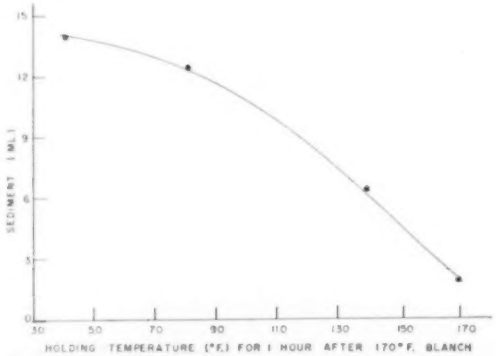

Figure 2. Sediment produced from canned beans which had been held at various temperatures for 1 hour between an initial 170° F blanch and a final 140° F blanch.

a blanching medium resulted in a toughening of beans. In one phase of our work we have compared the amount of sediment obtained from canned beans blanched at 170° F and 190° F in water and in McConnell's solution (500 ppm of calcium added as calcium chloride with the pH adjusted to 3.5 with citric acid). The use of the acidified calcium solution resulted in less sediment than from the water blanch controls. However, the sediment values resulting from the 190° F blanch in the calcium solution were higher than those found with the beans blanched at 170° F in either water or acidified calcium solution.

The short period of exposure (2 min) to the calcium of the blanch solution may have been responsible for the incomplete protection afforded by such a blanch. Further investigation showed that if the beans were soaked in a 1% calcium chloride solution prior to blanching the softening effect of the high temperature blanch could be avoided. (Table 5). Some time was needed for the calcium soak to be effective. Six hours of

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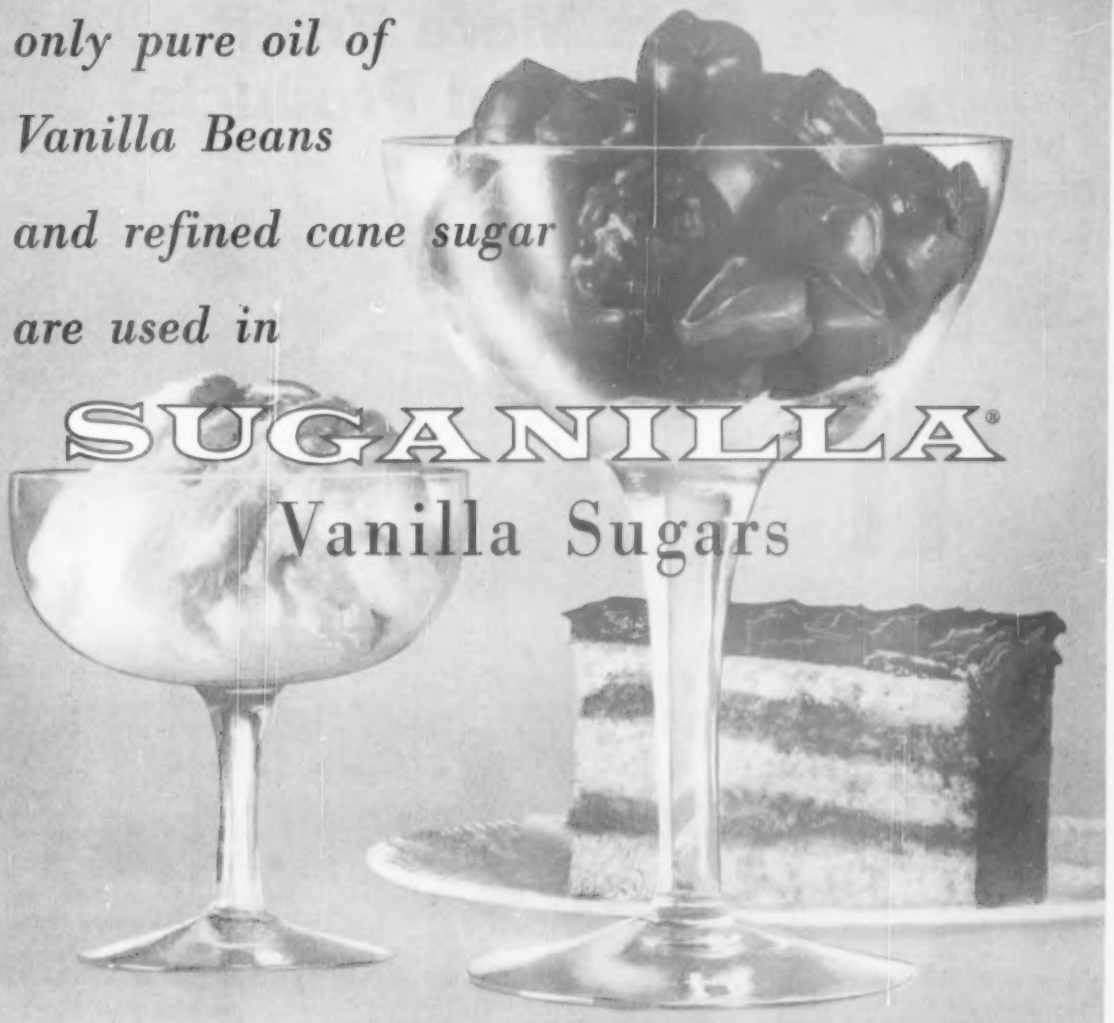

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TABLE 5

Results of 24 hour pre-treatment of beans with various reagents

Soak solution[1]	Blanch treatment, 2 minutes	Sediment
	(°F)	(ml)
Distilled water	170	10
Distilled water	210	13
1% calcium chloride	170	0
1% calcium chloride	210	2
1% sodium oxalate	170	21
1% sodium oxalate	210	35
1% calgon	170	20
1% calgon	210	31

[1] pH of solutions adjusted to 6.0.

soaking were required before sloughing following a 190° F blanch, was reduced to reasonable levels (Figure 3).

In contrast to the toughening effect of calcium treatments, soaking the beans in solutions of calcium sequestering chemicals such as oxalate and calgon accentuated sloughing (Table 5). Further experiments showed that beans could be soaked in oxalate for 24 hr, drained, rinsed, and then soaked 24 hr in 0.05 M calcium chloride solution with the result that sloughing following a 190° F blanch was avoided. This demonstrates that the oxalate acted through its effect on calcium of the bean pods rather than by removing cementing polysaccharides from between the cells.

Splitting. Tendency of the canned beans to slough was paralleled by the increased ease of splitting. The correlation coefficient between per cent split beans and ml of sediment was .95 and was significant when tested by the z-transformation *(6)*. At high blanching temperatures splitting became very severe (Table 1). On the other hand, the resistance to splitting of the beans blanched at low temperatures was quite marked. Attempts to split beans blanched at 170° F and lower often resulted in a breakage at layers other than the interface between the valves of the pods. The skins of the beans contribute to the adhesion of the valves but when skins were removed at the juncture of the valves there were still strong adhesive forces between the valves of beans blanched at the lower temperature.

Firmness. Firmness measurements on the canned beans (Figures 4 and 5) showed that here again blanching conditions had a marked effect on the physical character of the beans. In addition there were significant correlation coefficients of −.90 between pounds of pressure and ml of sediment and −.84 between pounds pressure and per cent split beans. It would seem that the effect of low temperature blanching was not confined to the skins and the interface between pod valves but was a general firming effect which took place throughout the pod.

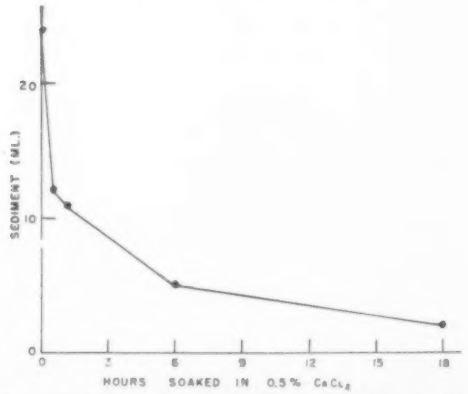

Figure 3. Effect on sediment of canned beans of soaking the beans for various times in 0.5% calcium chloride at 45° F prior to blanching at 190° F.

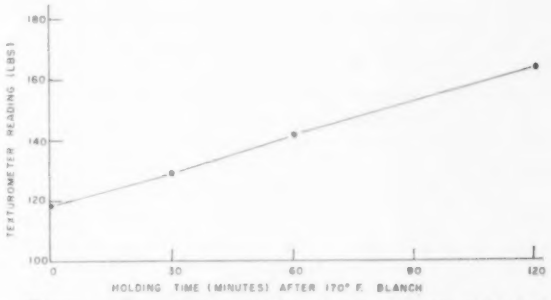

Figure 4. Texturometer reading of canned beans which had been held for various times at 80° F between an initial 170° F and a final 190° F blanch.

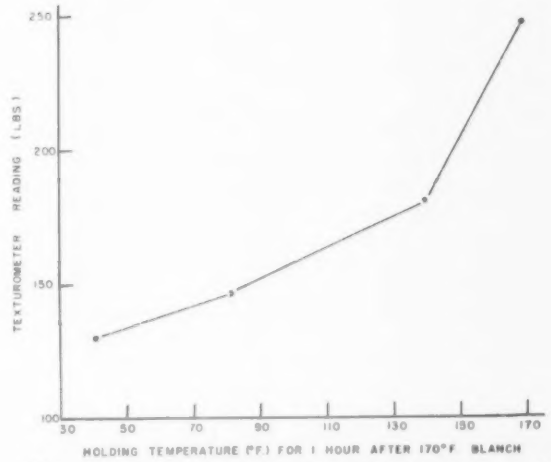

Figure 5. Texturometer reading of canned beans held at various temperatures between an initial 170° F blanch and a final 190° F blanch.

DISCUSSION

Results of these experiments indicate that the blanching conditions have a pronounced effect on the firmness of canned snap beans. Since firming continues after blanching at 170° F and the rate at which it proceeds depends upon the temperature at which the blanched beans are held it appears that either a diffusion or a chemical reaction is part of the firming process. Diffusion of some substance as an explanation is unlikely since toughening is stopped by the use of a higher temperature blanch at 190° F. The same fact suggests that the chemical reaction may be catalyzed by an enzyme.

There are also indications that pectic substances were involved in the changes seen in the physical properties of the beans. The firmness of the canned beans and the ease with which tissue can be sloughed off would appear to be related to the degree of adhesion between the cells. The middle lamella plays an important role in keeping cells together and evidence has been pointed out by Kertesz *(2)* that this structure is made up of water insoluble pectic substance similar in nature to calcium pectate. Sequestering

agents remove calcium from the middle lamella and so decrease the amount of insoluble pectate. This has been confirmed experimentally by Personius and Sharp *(4)* who demonstrated that use of oxalate caused a decreased adhesion between potato cells. The blanching effect may be related to a similar phenomenon in that the high temperature blanch could promote a loss of pectic substances from the middle lamella through diffusion, or the lower temperature blanch could increase the amount of pectate in the intercellular layer through enzyme action. The latter possibility is indicated by the present work since changes in the firmness of the pods continued during holding after the blanch at lower temperatures but not after blanching at 190° F or higher.

The firmness found in canned beans blanched at moderate temperatures may be undesirable. For this reason we believe more work should be done before suggesting that blanching temperature of 180° F or lower should be routinely used to avoid sloughing. Our experience indicates that the normal variation between lots and varieties of beans can lead to some tough beans if all beans are blanched at 180° F. A possible solution to the problem might be to give the beans a short blanch at 170–180° F followed by a holding period and a subsequent 2-min blanch at 190° F. However, such a procedure may not be practical from the standpoint of cost and sanitation. Use of calcium as an agent for preventing sloughing also has limitations, such as the long soaking period needed, equipment costs, process controls, and the need for approval of its use.

When sloughing occurs as a result of conventional processing and is severe enough to cause probable downgrading of the canned product, the observations made in this study may be of use in suggesting methods for decreasing the amount of sloughing. Blanching temperatures of 180° F or slightly lower and maintaining the beans at higher than usual temperatures, but below 170° F, between blanching and brine-filling would seem to be logical changes to make when a particular lot of beans tends to slough badly. Similar suggestions have been made by McConnell *(3)* as the result of his study. By using caution in introducing changes, the development of undesirable overall firmness in the canned bean can be minimized. It should be borne in mind that holding the blanched beans at relatively high temperatures would be of little value in decreasing the occurrence of sloughing if the initial blanch temperature was 190° F or higher. In cases where the above suggestions do not cause a decrease in sloughing there may be an unusual predisposition of the beans to have low intercellular adhesion. Basic causes for differences in tendency to slough of different lots and varieties of snap beans are now under investigation.

SUMMARY

Objective tests have been developed to give quantitative measures of the firmness of canned snap beans and their tendency to slough and split. These methods have shown that the blanching temperature was one of the most important factors affecting the sloughing of beans.

Beans were blanched at temperatures between 150° F and 210° F with the result that, as the temperature was raised, the tendency to slough and split increased and the firmness decreased. When blanching was carried out at temperatures below 180° F increased blanching time led to less sloughing, while at higher blanching temperatures greater sloughing was the result of longer blanching times.

The general firming effect of moderate temperature blanching continued to take place during the interval between blanching and retorting and was enhanced by holding the blanched beans at slightly elevated temperatures. Little or no change in firmness took place during holding periods following blanching at 190° F or higher.

The tendency of beans to slough was increased by soaking them in oxalate and Calgon solutions prior to blanching, while this tendency was decreased by soaking in a calcium chloride solution.

Acknowledgments

We wish to express our appreciation to Mr. George Meyers, Mr. Charles Sapienza, and Mr. Arthur Guest of Comstock Foods, Inc., for the advice and assistance given to us during this work. We also wish to thank Comstock Foods, Inc., for providing most of the beans used in this study. We are also indebted to Dr. Stanley Yeager of the Food Machinery Corporation for his suggestions and discussions.

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Application of Orthogonal Polynomials to Data on Palatability

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IN REGRESSION ANALYSES involving two variables, it is often necessary to fit a nonlinear regression curve to the data. By using orthogonal polynomials in this situation the goodness of fit of a straight line, quadratic, or higher degree curve, can be conveniently determined.

Davis and Elliot *(5)* applied orthogonal polynomials in fitting a quadratic curve to calibration data on vacuum of unopened cans. Several writers *(3, 7, 9)* present examples illustrating how to use orthogonal polynomials when the values of the independent variable are equally spaced; for example, Goulden calculates a polynomial equation estimating enzyme activity from pH, and Bennett and Franklin fit a regression curve to glass density at different temperatures.

The purpose of this paper is to illustrate the use of orthogonal polynomials with data on palatability in determining the simplest curve that appropriately represents the regression of one variable on another. In this example the values of the independent variable are equally spaced. A brief review of the method of orthogonal polynomials is first presented.

METHODOLOGY

The general regression equation is

$$\hat{Y} = \overline{Y} + b_1X + b_2X^2 + \ldots + b_rX^r \qquad (1)$$

where $\hat{Y}$ is an estimated value of Y, the dependent variable, $\overline{Y}$ is the mean of Y, X is the independent variable and the b's are partial regression coefficients.

As given in reference *(1)*, for example, this equation is changed to the orthogonal polynomial form

$$\hat{Y} = \overline{Y} + A_1P_1 + A_2P_2 + \ldots + A_rP_r \qquad (2)$$

where: A's are functions of the b's.
P's are orthogonal polynomials such that P_1 is a function of the first power of X, P_2 is a function of X and X^2, and so on.

Orthogonal polynomials have the following properties:

1. The sum of the values for each polynomial equals zero.
2. The sum of the cross products of any two polynomials equals zero.

RESULTS AND DISCUSSION

Example. The data for this example are taken from the results of a taste experiment made on fresh broccoli cooked electronically for four equally spaced times *(4)*.

Texture of broccoli stems was considered the most important characteristic. Therefore, it was necessary to determine the cooking time corresponding to best texture of stems, 5.0, in terms of the scoring scale.

Orthogonal polynomials were employed in calculating the regression equation of texture score on cooking time. The procedure is illustrated in the following steps:

Step 1: The problem is to determine whether r = 1, 2, or 3 in the regression equation

$$\hat{Y} = \overline{Y} + A_1P_1 + \ldots A_rP_r$$

where $\hat{Y}$ is an estimated texture score and X is the cooking time in minutes.

Step 2: Tables in *(2)* or *(6)*, for example, are consulted for the values of the orthogonal polynomial listed under n equals 4 where n refers to the number of values of X.

Step 3: Mean panel scores for texture, denoted by Y, and the polynomial values are shown in Table 1. The two fundamental properties of orthogonal polynomials are demonstrated in this table:

1. The sum of the values given for each polynomial equals zero; for example,
$$\Sigma P_1 = -3 - 1 + 1 + 3 = 0.$$
2. The sum of the cross products of two polynomials equals zero; for example, $\Sigma P_1P_2 = (-3)(1) + (-1)(-1) + (1)(-1) + (3)(1) = 0$.

Step 4: The A's are calculated from Table 1 as follows:

$$A_1 = \frac{\Sigma P_1 Y}{\Sigma P_1^2} = \frac{-3(7.60) + (-1)(5.20) + 1(3.85) + 3(2.85)}{(-3)^2 + (-1)^2 + (1)^2 + (3)^2} = \frac{-15.60}{20} = -.780$$

$$A_2 = \frac{\Sigma P_2 Y}{\Sigma P_2^2} = \frac{1.40}{4} = .350$$

$$A_3 = \frac{\Sigma P_3 Y}{\Sigma P_3^2} = \frac{-.70}{20} = -.035$$

Step 5: The sum of squares for "between cooking times" is:

$$\Sigma Y^2 - \frac{(\Sigma Y)^2}{n} = 107.7450 - \frac{(19.50)^2}{4} = 12.6825$$

This sum of squares is broken down into components of regression as follows:

A_1P_1, linear component:

$$A_1\Sigma P_1 Y = -.780(-15.60) = 12.1680$$

A_2P_2, quadratic component:

$$A_2\Sigma P_2 Y = .350(1.40) = .4900$$

[a] Present address: Diamond Ordnance Fuze Laboratory, Department of Army, Washington, D. C.

TABLE 1

Values of orthogonal polynomials and mean panel scores for texture of fresh broccoli cooked electronically

Cooking time X	Mean texture score[1] Ȳ	Orthogonal polynomial values		
		P_1	P_2	P_3
minutes				
3	7.60	−3	1	−1
6	5.20	−1	−1	3
9	3.85	1	−1	−3
12	2.85	3	1	1
Sum	19.50	0	0	0
$\bar{Y}$	4.88	....	....	....
Sum of squares	107.7450	20	4	20

Source: Values and sums of squares of the polynomials taken from tables in *(2)* or *(6)*.

[1] Scores above 5 denote degrees of toughness and below 5 degrees of softness on a 1–9 scoring scale *(4)*.

A_3P_3, cubic component:

$$A_3\Sigma P_3 Y = -.035(-.70) = .0245$$

These sums of squares and the corresponding degrees of freedom are incorporated in the analysis of variance table which also shows the sum of squares for deviations from regression (Table 2).

The goodness of fit of the straight line is examined by testing whether the linear component, A_1P_1, is significant. The goodness of fit of the quadratic and cubic curves are separately determined in a similar manner.

The F-test indicates that the linear and quadratic components are significant, but the cubic component is not.

Step 6: Since the quadratic component, A_2P_2, is the highest degree component that is significant, the regression equation of texture score on cooking time is

$$\hat{Y} = \bar{Y} + A_1P_1 + A_2P_2 = 4.88 - .780P_1 + .350P_2 \quad (3)$$

The expressions for P_1 and P_2, given in references *(1, 8)*, can only be used when $X = 1, 2, 3, 4$. In the example, $X = 3, 6, 9, 12$. Therefore, X must be coded to $X' = 1, 2, 3, 4$ by setting $X' = X/3$. The mean of the coded values is $\bar{X}' = 2.5$.

The constants, $k_1 = 2$ and $k_2 = 1$, enter into the expressions for P_1 and P_2, respectively, and are obtained from tables in *(2)* or *(6)*. Then

$$P_1 = k_1 (X' - \bar{X}') = 2(X' - 2.5) = \frac{2X}{3} - 5$$

and

$$P_2 = k_2 (X' - \bar{X}')^2 - \frac{n^2 - 1}{12}$$

$$= (X' - 2.5)^2 - \frac{15}{12} = \frac{X^2}{9} - \frac{5X}{3} + 5$$

To show how the quadratic regression equation is formed, the equation for a straight line will first be computed. The linear regression equation is

$$\hat{Y} = \bar{Y} + A_1P_1 = 4.88 - .780P_1$$

$$= 4.88 - .780\left(\frac{2X}{3} - 5\right) = 8.78 - .520X \quad (4)$$

By adding A_2P_2, which is $.350\left(\frac{X^2}{9} - \frac{5X}{3} + 5\right)$, to the linear equation, we obtain the quadratic regression equation

$$\hat{Y} = 8.78 - .520X + .039X^2 - .583X + 1.750$$

$$= 10.53 - 1.103X + .039X^2 \quad (5)$$

Thus, the quadratic equation differs from the linear only by the addition of $.039X^2 - .583X + 1.750$. The form of the quadratic equation illustrates that when orthogonal polynomials are used the regression equation does not have to be recomputed whenever other terms are added.

Step 7: Table 3 shows the scores estimated from the quadratic equation. To emphasize the form of this equation, estimated scores from the linear equation are also shown in the table. For a given cooking time, the estimated scores from the two equations differ only because of the term, $.039X^2 - .583X + 1.750$.

The straight line and quadratic curve are drawn through the points $(X, \hat{Y})$ and are shown in Figure 1.

TABLE 2

Analysis of variance: Partition of "between cooking times" into components of regression

Source of variation	Sum of squares	Degrees of freedom	Mean square	F
Between cooking times	12.6825	3	4.2275	81.93**
A_1P_1: Linear component	12.1680	1	12.1680	235.81**
Deviations from linear regression	.5145	2	.2572	
A_2P_2: Quadratic component	.4900	1	.4900	9.50**
Deviations from quadratic regression	.0245	1	.0245	
A_3P_3: Cubic component	.0245	1	.0245	<1
Deviations from cubic regression	0	0	.....	.....
Error[1]	3.0950	60	.0516	

** Significant, 1% level.

[1] Judge x Sample interaction, furnished by a complete analysis of variance.

The straight line apparently gives a satisfactory fit. However, as shown in Table 2, the quadratic curve is a significantly better fit. Furthermore, Figure 1 shows that the fit of the quadratic is better particularly in the region of 5.0 for texture scores. In the example, this is the most important region for which estimates are desired. Therefore, the quadratic rather than the linear equation furnishes more precise estimates of texture scores.

According to the quadratic equation, the score for best texture, 5.0, was estimated for broccoli cooked 6.5 minutes (Table 3). This cooking time was also

TABLE 3

Observed and estimated scores for texture of fresh broccoli cooked electronically

Cooking time X	Observed scores[1] Ȳ	Scores estimated from regression equation	
		Linear[2]	Quadratic[3]
minutes			
3	7.60	7.22	7.57
6	5.20	5.66	5.32
6.5	.....	5.40	5.01
7.3	.....	4.98	4.55
9	3.85	4.10	3.76
12	2.85	2.54	2.91

[1] Scores above 5 denote degrees of toughness and below 5 degrees of softness on a 1–9 scoring scale *(4)*.

[2] $\hat{Y} = 8.78 - .520X$.

[3] $\hat{Y} = 8.78 - .520X + .039X^2 - .583X + 1.750$.

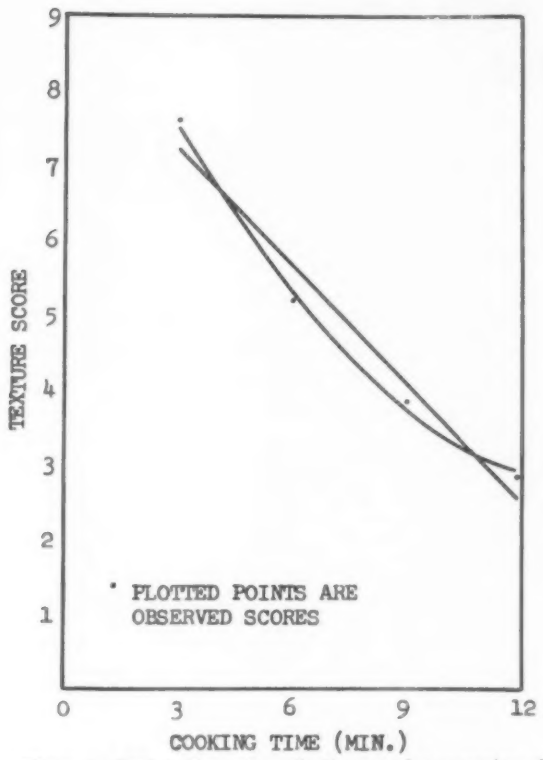

Figure 1. Straight line and quadratic curve for regression of texture score on cooking time of fresh broccoli.

used in estimating values for color, flavor, and ascorbic acid of fresh broccoli cooked electronically *(4)*. The precision gained by using 6.5 minutes as the time corresponding to best texture is especially important when comparisons are made with other methods of cooking fresh broccoli to best texture.

SUMMARY AND CONCLUSIONS

Orthogonal polynomials are used to evaluate panel mean scores for texture of stems of fresh broccoli cooked electronically for four equally spaced times. The example illustrates how the sum of squares for "between cooking times" is partitioned into independent sums of squares for linear, quadratic, and cubic components of regression. It also shows how orthogonal polynomials are applied in calculating the quadratic regression equation, $\hat{Y} = 10.53 - 1.103X + .039X^2$, for estimating scores for texture from various cooking times (minutes).

Orthogonal polynomials constitute a convenient method for determining the goodness of fit of a straight line, quadratic, or higher degree regression curve to data on palatability and to other types of data. The method is useful in non-linear regression involving two variables. By using orthogonal polynomials, the regression equation does not have to be recomputed whenever other terms are added.

Acknowledgment

The authors wish to thank Miss Gladys Gilpin and Dr. James P. Sweeney of the Food Quality Laboratory of the Human Nutrition Research Division for presenting the problem and providing the data used.

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The Compatibility of Dehydrated Army Rations with Chlorinated and Iodine-Treated Surface-Waters

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THE HIGHLY MOBILE SOLDIER in combat is likely to have to eat as an individual or as a member of a small unit. "The soldier in the combat zone, however, does not spend all his time shooting and being shot at. Much of the time he is moving from one place to another or simply holding a position, often in an area subject to attack but not actually engaged. In this situation, he can usually prepare and eat a meal if the preparation is simple enough" *(9)*. Food preparation for the combat soldier is made a relatively simple task by the use of precooked dehydrated rations, since the addition of potable hot water to the dehydrated ration, with a short period required for soaking, is all that is necessary before serving.

In a previous study by the authors *(8)* on the compatibility of dehydrated army rations with chlorinated and iodine-treated ground-waters, it was determined that the emergency use of iodine-treated and chlorinated ground-waters of high mineral concentration did not impart any serious objectionable taste or odor to the precooked rehydrated foods tested. Since ground-water is only one of the possible sources of water available to the soldier, it was decided to extend this study to include the sensory evaluation of chlorinated and iodine-treated surface-waters obtained from various U. S. swamp and river sources and used to reconstitute the same dehydrated foods evaluated in the earlier study.

EXPERIMENTAL

Materials. Three types of dehydrated foods were used for screening purposes in this study: hot cocoa beverage powder, hot cream of onion soup, and cold orange juice powder, synthetic, Type I, with ascorbic acid. In addition, chili containing dehydrated ground-beef and dehydrated green snap beans were also evaluated. The types of surface-waters used in this study included 3 swamp and canal waters and 5 river waters. Swamp and canal waters were selected as sources of water containing a high concentration of color and organic matter, and river waters as sources of industrial pollutants. The swamp and canal waters sources included: Great Dismal Swamp near Portsmouth, Va.; Hillboro Canal and Lake Okechobee, Belle Glade, Fla.; and West Palm Beach, Fla. The river water sources included: Mississippi River at E. St. Louis, Ill.; Missouri River at Kansas City, Kan.; Delaware River at Philadelphia, Penna.; Ohio River at Cincinnati, Ohio; Ohio River at Huntington, W. Va.

A map indicating the locations of all the water sites used throughout this study, including the ground-waters previously reported *(8)*, is shown in Figure 1. The river sampling stations were generally located at the water-works intake sites. These stations could not be segregated in terms of specific industrial pollutants since effluents would be thoroughly mixed by the time they reached the sampling sites. Consequently, river water samples represented considerable variation in quality.

The standard iodine tablet used in these tests contains 19.3 to 21.3 mg of tetraglycine hydroperiodide, 82.5 to 92.3 mg of sodium acid pyrophosphate, and up to 6.0 mg of talc. One iodine tablet when dissolved in a canteen (1 quart) of water yields an average of 8.0 mg of iodine *(6)*. The source of chlorine used in these tests was calcium hypochlorite, vacuum packed 0.45 to 0.55 g in a glass tube; this was sufficient to disinfect one Lyster bag (30 to 35 gal of water) at a concentration of 1 mg/l chlorine *(4, 5)*.

Methods. Chemical analyses of all the waters used were carried out in accordance with the procedures outlined in *Standard Methods for Examination of Water, Sewage, and Industrial Wastes (1)*. Side reactions are known to occur in the chlorination of natural waters in which HOCl combines with ammonia or compounds containing the amino group (NH_2) to form chloramines, or the chlorine reacts with substances which reduce chlorine to chloride. The formation of chloramines, while leaving the concentration of titratable chlorine unchanged, nevertheless reduces its disinfecting power materially *(3)*. Iodine, however, has the important advantage of maintaining substantially constant germicidal efficiency in waters with high pH values and in waters containing ammonia or other nitrogenous materials since the formation of iodamines between ammonia or amino compounds and I_2 does not occur under the usual conditions in water disinfection. Iodine and chlorine disinfectants suffer alike in the presence of organic color or other reducing materials. The reduction of halogenating agents by tannins and similar substances found in water that has come into contact with vegetable debris is an example of this reaction *(2)*. Where organic matter in natural water cannot be removed by coagulation or filtration prior to disinfection under emergency conditions, allowance must be made for the possible high chlorine and iodine demand of the water to be disinfected, or for the presence in it of ammonia and amines in the case of chlorine application. This was accomplished in these studies by treating the surface-waters with 16 and 24 mg/l of iodine and 5 and 10 mg/l of chlorine in order to allow for halogen demand of the surface waters being evaluated.

For the comparison of tastes and odors of halogen-liberating compounds, it became necessary to adopt parameters or yardsticks which would reflect the reactions of the olfactory and taste senses. The parameters employed were those included in the hedonic scale as reported previously *(8)*. A laboratory sensory panel consisting of 7 untrained tasters was formed to predict the relative acceptance of waters using the hedonic scale.

Each member of the taste panel was given a copy of the hedonic scale and asked to use this scale to indicate his attitude toward each sample by checking at the point on the scale which best described his feeling about the taste and odor of each sample. Each subject rated each of the three dehydrated foods (hot cocoa beverage powder, hot cream of onion soup, and cold orange juice powder, synthetic, Type I) first reconstituted with distilled water containing 0, 16, and 24 mg/l of iodine and then another sample with 0, 5, and 10 mg/l of chlorine. Each test was then repeated, but this time the raw surface-water under investigation was substituted for the dis-

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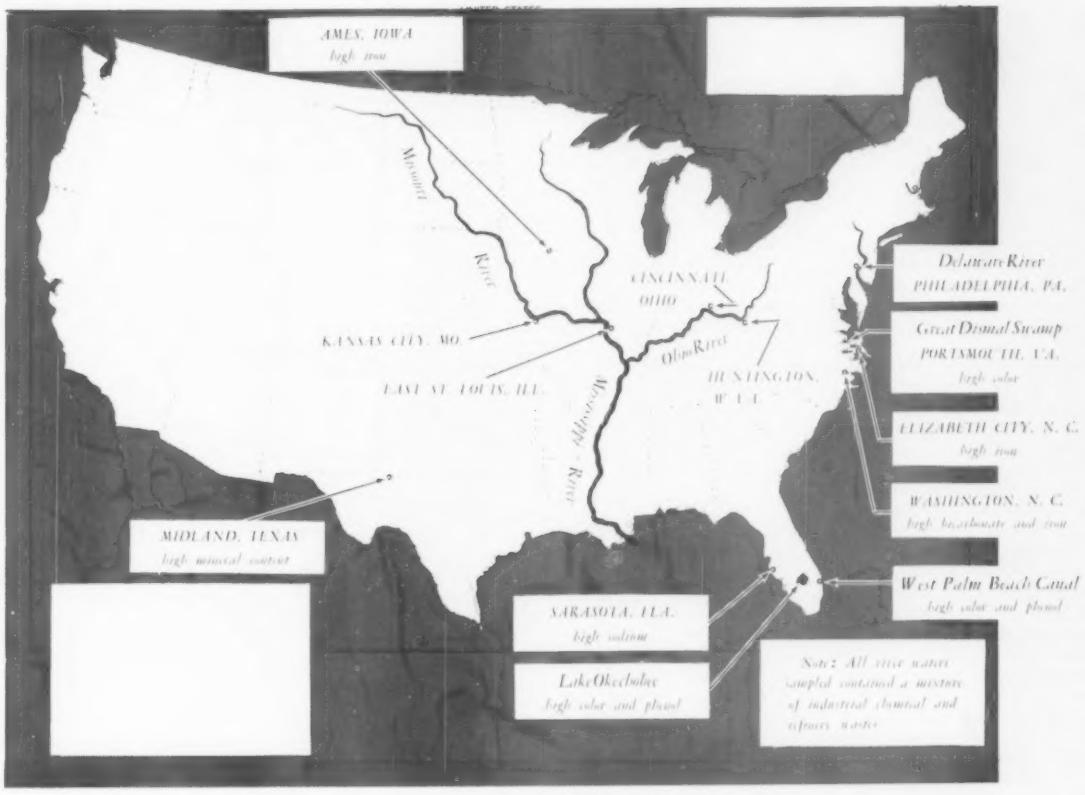

Figure 1. Water sample site locations.

tilled water. Only the Ohio River and the Mississippi River samples were used for the chili and green snap beans, respectively, due to the limited amount of water available from the other sources.

The hedonic ratings assigned each food by the panel members were tabulated and the median value obtained for comparative purposes. Each subject made 4 judgments at a sitting and no more than 2 sittings per day was asked of each subject.

Each raw surface-water control sample (containing no halogen) before being used was first filtered through a Seitz filter to remove any possible pathogenic organisms that might be present. All other raw-water samples were rendered potable by the addition of either iodine or chlorine prior to being used in the reconstitution of the dehydrated foods.

Conditions such as the temperature, quantity of sample, and concentration of halogen were all controlled. Each food was reconstituted in accordance with the directions appearing on the package of the dehydrated foods tested. Each member of the sensory panel was served 20 to 25 ml portions of each food for evaluation. Hot cocoa beverage and hot onion soup were served at 80° C (176° F) and the cold orange juice powder was served at 5° C (41° F). Temperature of samples at time of consumption varied slightly from the serving temperatures depending upon the total serving time involved and the consumption time required by each panel member.

RESULTS

In 1946 the *U. S. Public Health Service Standards for Drinking Water* became the recognized guide to public water-supply quality. It is impractical to control and to maintain the quality of the water-supply obtained for temporary-emergency use in accordance with these standards other than being certain the water is free from pathogenic organisms. In most cases these waters will be from the most readily available supply including swamps, rivers, streams, lakes, ditches, etc. Some of the effects of using water not meeting these criteria were discussed in an earlier paper *(8)*.

Table 1 characterizes and compares some of the suggested *U. S. Public Health Standards for Drinking Water* with the results of the chemical analyses of the surface waters under investigation. Chemical analyses of the river waters were furnished by each participating city in the Public Health Service Water Quality Basic Data Program through the Robert A. Taft Sanitary Engineering Center, Cincinnati, Ohio. All other chemical analyses were conducted in the Chemicals & Plastics Division of this Center.

Tastes, odors, and appearance of surface-waters are generally indicative of a high degree of objectionable features in

TABLE 1

Comparison of some of the U. S. Public Health Standards suggested for drinking water with analyses of raw surface-waters

	Color	Alkalinity (As $CaCO_3$) mg/l	Turbidity mg/l	Phenol mg/l
Upper Permissible Limits Recommended by US Public Health	40	120	10	0.001
Great Dismal Swamp	225	.....	.....	.....
Hillboro Canal & Lake Okechobee	125	.....	.....	0.09
West Palm Beach	80	.....	.....	0.06
Mississippi River	44	174	55	.....
Delaware River	55	31	32	.....
Ohio River (Huntington, W. Va.)	50	23	260	.....
Ohio River (Cincinnati, Ohio)	15	26	100	.....
Missouri River	12	174	290	.....

water supply when little is known of the sources and general environment. Tastes and odors in water are usually associated with the presence of pollution or other objectionable matter such as organic matter, plankton, or industrial wastes. Presence of phenol in water is also known to accentuate the taste and odor of both chlorine and iodine when added to water for disinfection purposes. During emergency conditions, surface-waters contaminated with high organic matter and industrial wastes (as reported in Table 1) and exceeding limits recommended by *U. S. Public Health Standards for Drinking Water* will have to be used in reconstituting dehydrated foods without benefit of any additional treatment.

Tables 2 and 3 list the average hedonic ratings assigned the dehydrated foods reconstituted with the 3 swamp and canal waters and 5 river waters. In examining the average hedonic ratings in Tables 2 and 3, the following observations may be made.

The only food that received an average hedonic taste rating in the dislike category when reconstituted with chlorinated Great Dismal Swamp water was the orange juice, synthetic, type 1. All the other dehydrated foods reconstituted with either iodine-treated or chlorinated Great Dismal Swamp water received taste and odor ratings ranging between *neither like nor dislike* and *like moderately*.

In comparing the control samples for each set of tests (Great Dismal Swamp water containing no halogen and distilled water containing no halogen), it will be noted that, in every instance for both taste and odor, the distilled water samples were given only a slight preference over the Great Dismal Swamp water samples. In no instance was there more than a one hedonic scale difference between the Great Dismal Swamp controls and the distilled water controls for both taste and odor. This would indicate that any greater difference noted in the taste and/or odor ratings in comparing halogenated Great Dismal Swamp water with halogenated distilled water is a result of the added halogen. No apparent chemical or physical difference in color, appearance, or consistency could be detected in any of the rehydrated foods tested when rehydrated with the halogenated Great Dismal Swamp water vs halogenated distilled water.

From the results shown in Tables 2 and 3, it can readily be seen that both the iodine-treated and chlorinated Hillboro Canal-Lake Okechobee water, used to reconstitute the cocoa beverage powder, adversely affects the taste of the cocoa, but has only a minor effect on its odor. A similar pattern exists when orange juice, synthetic, Type I is reconstituted with iodine-treated and chlorinated Hillboro Canal-Lake Okechobee water. However, iodine appears to adversely affect the taste and odor of the orange juice more at the lower iodine concentration level (16 mg/l) than does the low level of chlorine (5 mg/l). The higher concentrations of iodine (24 mg/l) and chlorine (10 mg/l) seem to have about the same effect on the taste of the orange juice *(neither like nor dislike)*, while the odor of the orange juice at the same level of iodine appears to be less acceptable than the same level of chlorine. Results of the sensory ratings for cream of onion soup indicate as in previous tests that the taste and odor of the soup mask the odor and flavor of both chlorine and iodine. Since the Hillboro Canal-Lake Okechobee water contained a relatively high concentration of phenol, (0.09 mg/l) and color (22.5 units) and it is known that the presence of phenol and organic matter accentuate the odor and taste of both chlorine and iodine, it is reasonable to assume that the presence of phenol and organic matter in this water contributed to the low hedonic ratings assigned cocoa beverage powder and orange juice. The hedonic ratings reported for the Hillboro Canal-Lake Okechobee water were the lowest ratings reported throughout this study.

In comparing the control samples for each set of tests (Hillboro Canal-Lake Okechobee containing no halogen and distilled water containing no halogen), it will be noted that, in every instance for both taste and odor, the distilled water samples were given only a slight preference over the test samples. This would indicate that any great difference noted in the taste and/or odor ratings in comparing halogenated Hillboro Canal-Lake Okechobee water with halogenated distilled water is a result of the added halogen. No apparent chemical or physical differences in color, appearance, or consistency could be detected in any of the rehydrated foods tested.

Hedonic ratings reported in Tables 2 and 3 indicate that the use of iodine-treated and chlorinated West Palm Beach water in the reconstitution of cocoa beverage powder and cream of onion soup have only a slight to no effect on the taste and odor of these two foods. A slight preference for orange juice, synthetic, Type I reconstituted with chlorinated and iodine-treated distilled water vs. the West Palm Beach water is noted, but this is not considered serious since the lowest rating is in the *neither like nor dislike* category. The West Palm Beach water also contained 0.06 mg/l of phenol, but the color content was considerably lower than the Hillboro Canal-Lake Okechobee water. It is therefore concluded that chlorinated and iodine-treated waters of the composition tested impart no serious objectionable taste and odor to the three dehydrated foods used in this evaluation.

TABLE 2

Average hedonic ratings for reconstituted dehydrated foods with iodine-treated surface-waters

Dehydrated food tested	Distilled water Iodine mg/l			Great Dismal Swamp Iodine mg/l			Hillboro Canal-Lake Okechobee Iodine mg/l			West Palm Beach Iodine mg/l			Missouri River Iodine mg/l			Mississippi River Iodine mg/l			Delaware River Iodine mg/l			Ohio River at Cincinnati, Ohio Iodine mg/l			Ohio River at Huntington, W. Va. Iodine mg/l		
	0	16	24	0	16	24	0	16	24	0	16	24	0	16	24	0	16	24	0	16	24	0	16	24	0	16	24
Cocoa Beverage Powder																											
Taste	8.1	8.0	7.0	7.1	6.1	6.4	6.7	3.8	4.6	7.9	5.7	6.3	7.1	3.9	4.6	7.7	5.4	6.7	7.3	5.8	6.9	7.6	7.6	7.5	7.4	7.0	5.3
Odor	8.1	7.3	7.9	7.4	7.1	7.4	7.3	6.7	6.9	7.9	7.1	7.3	7.3	7.0	6.9	7.6	7.1	7.4	7.1	6.7	7.0	7.6	7.4	7.6	7.3	7.3	7.3
Orange Juice Synthetic Type I																											
Taste	7.4	6.7	7.3	6.6	6.0	5.1	7.2	4.2	5.5	7.3	5.7	7.0	7.0	6.3	6.1	7.1	5.9	6.4	7.4	7.0	6.7	7.1	6.6	7.0	7.6	7.6	7.0
Odor	7.4	7.3	7.3	6.7	6.9	6.6	7.2	4.7	5.5	7.4	7.3	7.3	7.0	7.0	7.1	7.1	7.1	7.1	7.3	7.1	7.0	7.0	6.6	7.0	7.4	7.4	7.3
Cream of Onion Soup																											
Taste	7.9	7.4	7.4	7.1	5.7	5.6	8.0	7.4	6.4	7.9	6.7	6.0	7.7	7.3	7.6	7.4	6.4	7.1	7.7	7.0	7.7	7.6	7.1	7.6	7.6	7.0	7.6
Odor	7.4	8.0	8.0	7.7	7.4	7.3	7.7	7.4	7.3	7.4	7.4	7.1	7.7	7.7	7.6	7.4	7.1	7.4	7.7	7.7	7.7	7.6	7.6	7.6	7.6	7.0	7.6
Snap Green Beans																											
Taste																									6.9	6.6	6.6
Odor																									6.4	6.4	6.1
Chili																											
Taste																8.0	8.0	8.0									
Odor																7.6	7.6	7.6									

Hedonic Scale

9—Like extremely
8—Like very much
7—Like moderately
6—Like slightly
5—Neither like nor dislike
4—Dislike slightly
3—Dislike moderately
2—Dislike very much
1—Dislike extremely

TABLE 3

Average hedonic ratings for reconstituted dehydrated foods with chlorinated surface-waters

Dehydrated food tested	Distilled water Chlorine mg/l			Great Dismal Swamp Chlorine mg/l			Hillboro Canal-Lake Okeechobee Chlorine mg/l			West Palm Beach Chlorine mg/l			Missouri River Chlorine mg/l			Mississippi River Chlorine mg/l			Delaware River Chlorine mg/l			Ohio River at Cincinnati, Ohio Chlorine mg/l			Ohio River at Huntington, W. Va. Chlorine mg/l		
	0	5	10	0	5	10	0	5	10	0	5	10	0	5	10	0	5	10	0	5	10	0	5	10	0	5	10
Cocoa Beverage Powder																											
Taste	8.1	8.0	8.0	7.3	5.1	5.0	6.9	4.0	6.9	8.0	7.6	7.9	7.4	7.3	5.0	7.6	7.0	5.1	7.9	7.7	6.9	7.6	6.1	6.7	7.6	6.9	6.0
Odor	7.9	8.0	8.0	7.6	6.1	6.4	7.4	7.1	7.4	8.0	7.9	7.9	7.3	7.3	6.3	7.9	7.0	6.9	7.7	7.7	7.4	7.7	7.7	7.6	7.4	7.4	7.4
Orange Juice Synthetic Type I																											
Taste	7.4	7.3	6.4	6.4	4.7	5.1	7.4	6.0	5.7	7.1	5.7	5.9	7.6	7.4	7.6	7.4	6.3	5.9	7.0	6.9	6.9	7.4	6.7	5.9	7.6	7.0	7.3
Odor	7.4	7.4	7.0	7.0	6.3	5.9	7.4	6.4	6.7	7.0	7.0	6.4	7.4	7.4	7.4	7.4	7.4	7.4	6.9	6.6	6.9	7.7	7.7	7.7	7.4	7.4	7.4
Cream of Onion Soup																											
Taste	8.2	7.9	8.0	7.3	7.0	6.1	7.7	8.0	7.9	8.0	7.9	7.4	7.7	7.7	7.4	7.7	7.4	7.7	7.1	7.9	7.7	8.0	7.6	7.6	7.6	7.4	7.1
Odor	8.2	7.9	8.0	7.6	7.3	7.1	8.0	8.1	8.0	8.0	7.9	8.0	7.7	7.1	7.7	7.7	7.4	7.3	7.7	7.9	7.7	7.7	7.9	7.7	7.6	7.4	7.3
Snap Green Beans																											
Taste																									6.6	6.3	6.1
Odor																									6.4	6.1	6.0

Hedonic Scale

9—Like extremely
8—Like very much
7—Like moderately
6—Like slightly
5—Neither like nor dislike
4—Dislike slightly
3—Dislike moderately
2—Dislike very much
1—Dislike extremely

Average hedonic ratings in Tables 2 and 3 for the Missouri River water showed that the only food which resulted in any significant difference with the use of iodine-treated Missouri River water was the cocoa beverage powder. Taste ratings of *dislike moderately* and *dislike slightly* were assigned the water containing 16 and 24 mg/l of iodine, respectively. Use of Missouri River water in the reconstitution of the cocoa beverage powder also showed some slight drop in taste acceptability at the 10 mg/l of chlorine level. The other foods showed no appreciable taste or odor difference in acceptability when chlorinated Missouri River water was used.

Results with the Mississippi River water (see Tables 2 and 3) show that the test foods were rated just slightly below the comparable halogenated distilled water samples. The lowest taste rating given the Mississippi River water was in the *neither like nor dislike* category; the lowest odor rating was in the *like slightly* category.

Again referring to Tables 2 and 3, it is noted that the reconstitution of the cocoa beverage powder, with iodine-treated Delaware River water caused some slight decrease in taste acceptability at the 16 mg/l of iodine level. However, all the other foods reconstituted with both chlorinated and iodine-treated Delaware River water received taste-odor ratings ranging between *like slightly* and *like very much*.

The hedonic ratings assigned the screening foods rehydrated with the chlorinated and iodine treated Ohio River water (Cincinnati, Ohio) as summarized in Tables 2 and 3 show that they ranged between *like slightly* and *like very much* except for the 10 mg/l chlorinated sample used in the rehydration of the orange juice, synthetic, Type 1. A taste rating of *neither like nor dislike* was assigned this sample.

Tables 2 and 3 summarize the hedonic ratings for another sample of Ohio River water obtained at Huntington, W. Va. Again, taste and/or odor ratings for the chlorinated and iodine-treated river water used in the rehydration of the dehydrated screening foods ranged between *like slightly* and *like very much* except for cocoa beverage powder reconstituted with the Ohio River water containing 24 mg/l of iodine which received an average taste rating of *neither like nor dislike*.

Dehydrated snap beans, Type I, Style I (MIL-B-25011) rehydrated with both chlorinated (0, 5, and 10 mg/l) and iodine (0, 16, and 24 mg/l) treated Ohio River (Huntington, W. Va.) water gave an average taste rating of *like slightly* for both taste and odor.

Chili was prepared using a standard receipe with beef, ground, precooked, dehydrated (Experimental—Code No. 71512) as the only dehydrated component. The Mississippi River water treated with iodine (0, 16, and 24 mg/l) was used to rehydrate the beef. The chili received an average taste rating of *like very much* and an average odor rating of *like moderately* at all levels of iodine including the control (no iodine).

From the results tabulated in Tables 2 and 3, it can be seen that the use of chlorinated or iodine-treated surface-waters such as tested in this study do not impart any appreciable amount of objectionable tastes or odors to the dehydrated foods reconstituted with these waters. The only exception to this statement was the iodine-treated Hillboro Canal-Lake Okechobee and Missouri River waters used in the reconstitution of cocoa beverage powder. Average hedonic taste ratings of *dislike moderately*, and *dislike slightly* were assigned the 16 mg/l and 24 mg/l iodine concentrations, respectively.

DISCUSSION

Results reported in this study have been based on the average hedonic ratings obtained throughout the course of this project in evaluating the compatability of iodine-treated and chlorinated ground and surface-waters using three dehydrated foods as screening tools; namely, cream of onion soup, cocoa beverage powder, and synthetic orange juice. Additional dehydrated foods were used with some of the waters. These foods were snap green beans and ground precooked beef. Three water samples from each of the 3 types of water with halogen concentrations of zero (controls) and 5 mg/l chlorine and 16 mg/l iodine,

TABLE 4

Analysis of variance

Variance due to:	Deg. f	Sum of squares	Mean square	F ratios
Food	2	1636.1	818.1	25.1***
Halogen	2	2096.3	1048.2	32.2***
Interaction	2	1271.4	635.7	19.5***
Water with food	4	937.0	234.3	7.2*
Water with Halogen	4	695.2	173.8	5.3*
Food with Halogen	4	451.0	112.8	3.5
Residual	8	260.4	32.6	
Total	26	7347.4		

*** Very highly significant.
* Significant.

TABLE 5

Consolidated average hedonic taste ratings

	GROUND			RIVER			SWAMP		
	Control	Chlorine	Iodine	Control	Chlorine	Iodine	Control	Chlorine	Iodine
Cream of Onion Soup									
Average	7.5	7.2	7.5	7.8	7.7	7.1	7.4	7.6	6.6
Extremes	9-5	9-3	9-3	9-6	9-6	8-4	9-4	9-6	9-3
Cocoa Beverage Powder									
Average	7.8	7.4	7.3	7.2	7.1	5.7	7.0	5.6	5.1
Extremes	9-7	8-2	8-3	8-2	9-4	8-3	9-3	8-2	8-2
Synthetic Orange Juice Type I									
Average	7.0	5.8	6.8	7.0	7.0	6.6	6.6	5.5	5.3
Extremes	9-2	7-2	8-2	9-6	8-4	8-4	9-4	8-3	7-3

Hedonic Scale

9—Like extremely
8—Like very much
7—Like moderately
6—Like slightly
5—Neither like nor dislike
4—Dislike slightly
3—Dislike moderately
2—Dislike very much
1—Dislike extremely

and utilizing the 3 screening foods, were selected for analysis of variance in order to determine whether the use of halogenated ground-or surface-waters would impart an off-flavor or off-odor to the end product to a significant extent. A list of the water sources is as follows: 1. Ground-waters (Sarasota, Fla., Washington, N. C., Elizabeth City, N. C.); 2. Swamp waters (Hillboro Canal-Lake Okechobee, Fla., West Palm Beach, Fla., Great Dismal Swamp); 3. River waters (Ohio River, Cincinnati, Ohio, Delaware River, Philadelphia, Penna., Missouri River, Kansas City, Kansas).

The 5 mg/l chlorine and 16 mg/l iodine concentrations were chosen because they represent the highest concentrations currently being used in the field for individual emergency water purification.

The analysis of variance, Table 4, supports the conclusion that there are real differences in taste preference produced by type of water, type of food, and addition of halogen. There is also an interaction between water and food, and between water and halogen that affects taste preferences which are not merely due to chance variation.

A table of the average hedonic ratings used for analysis of variance is given in Table 5 and presented graphically in Figure 2. Each number represents an average of 21 individual ratings.

It can be seen from Figure 2 that foods rehydrated with swamp water were less acceptable than those rehydrated with ground and river waters, and that the control samples were generally more acceptable than the halogen treated samples. In no case, however, did any of the average ratings fall below 5 or into the *dislike category* although low individual ratings were given in nearly all of the tests, including the controls as indicated by the range of ratings listed in Table 5.

CONCLUSION

Thus, it may be concluded that no particular combination of water and halogen with any of the foods could be regarded as unacceptable even though some of the combinations had a real effect on reducing the excellence of the flavor of screening foods. Since none of the average scores fell into the hedonic *dislike* category or below, it must be assumed that the flavor of all the samples was satisfactory under the conditions

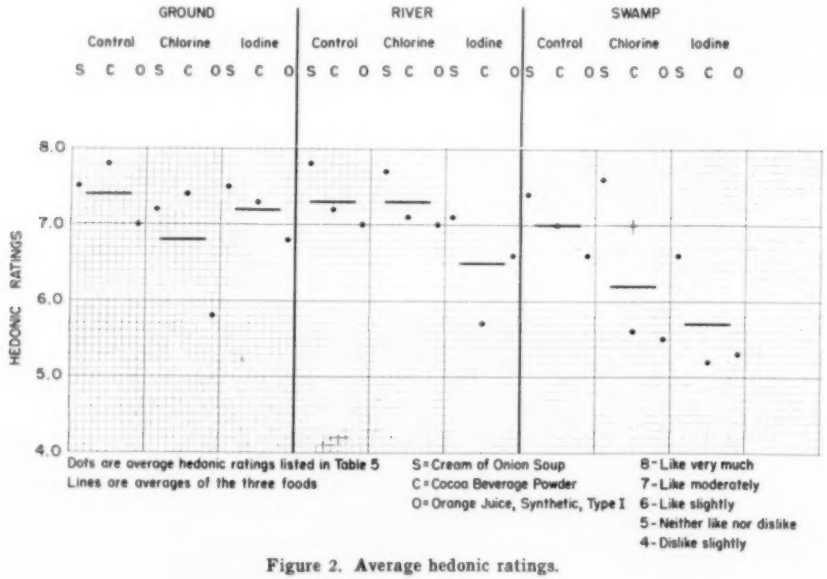

Figure 2. Average hedonic ratings.

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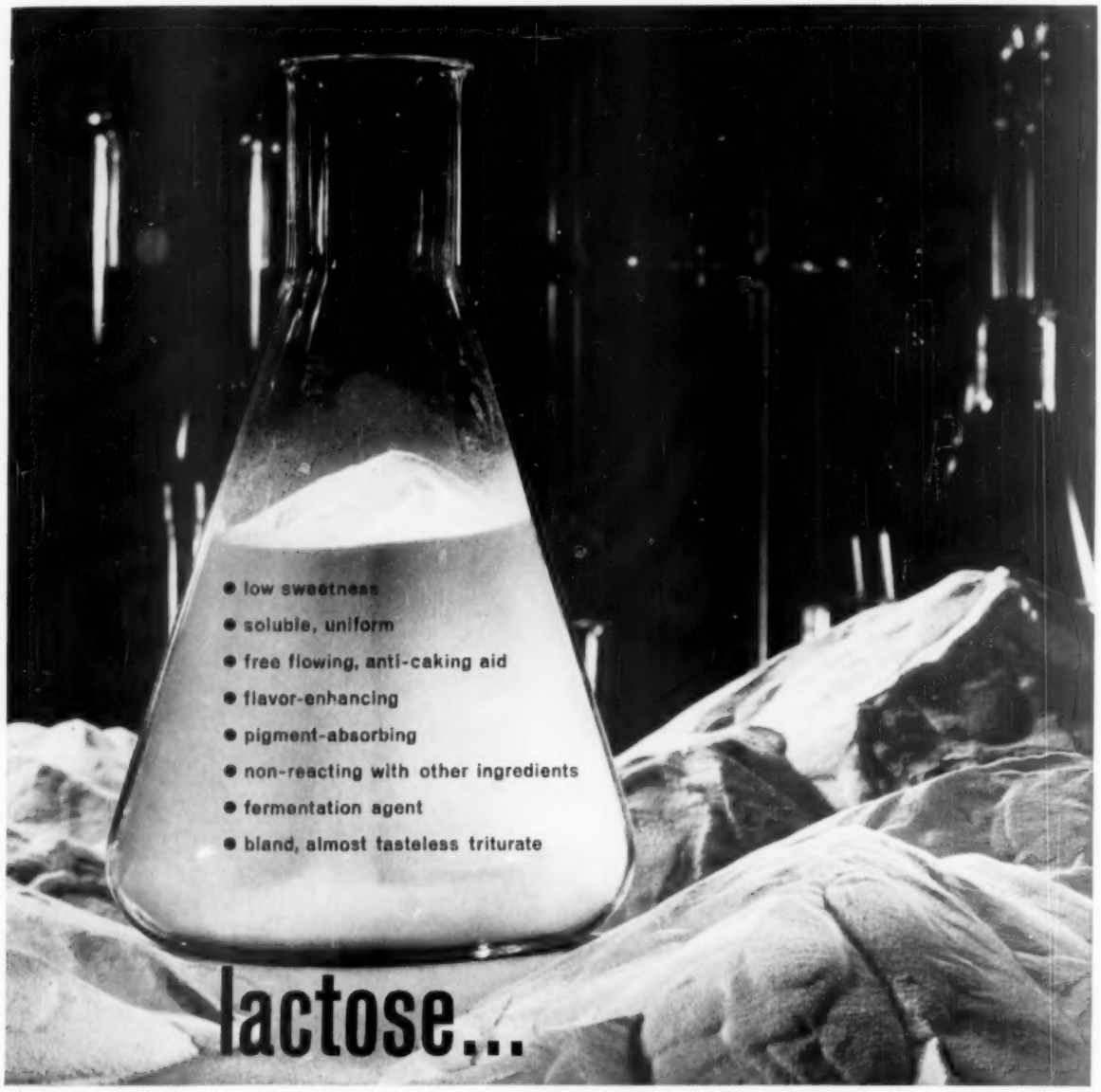

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of the experiment, and that the use of the average hedonic value has had practical and valid application throughout the course of this study as is evidenced by the number and relatively constant results obtained in these tests.

Acknowledgments

The authors wish to express their appreciation to the following for their cooperation and support in furnishing the water samples used in this investigation: Mr. Clarence Throop, Water Superintendent, Belle Glade, Fla.; Mr. X. D. Murden, Superintendent, Portsmouth Water Department, Portsmouth, Va.; Mr. J. G. Simmons, Superintendent, W. Palm Beach Water Department, Fla.; Mr. Ralph C. Palange, Asst. Chief, Water Supply and Water Pollution Program, and Mr. Stephen Megregian, Robert A. Taft Sanitary Engineering Center, 4676 Columbia Parkway, Cincinnati 26, Ohio. The authors are indebted to Dr. A. P. Black, Res. Prof. of Chemistry, University of Florida, Gainesville, Fla. for his assistance in the selection of the swamp and canal waters used in this study.

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Color of Capsicum Spices

(Manuscript received October 7, 1959)

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The methods usually employed for evaluating the color of capsicum spices are visual methods based upon comparison of the color of a diluted extract with that of a specially prepared potassium dichromate-cobaltous chloride solution *(2)* or with combinations of Lovibond glasses that match the color of the solution *(3, 4)*. Visual methods are always subject to personal factors and the difficulties of comparing the color of the extract with that of the standard solutions or color glasses. These usually differ somewhat in hue or chromaticity.

Recently, spectrophotometric methods have been proposed. In 1952 Moster and Prater *(3)* proposed a spectrophotometric method based upon transmittance measurements at 569, 577.5 and 663 millimicrons which when substituted in an equation give what the authors called Gentry units. The Gentry units could be correlated with Lovibond Red values. In 1954 Shuster and Lockhart *(8)* showed that the coloring matter extracted from capsicum had a characteristic absorption in the region of 460 millimicrons and that measurements in this region correlated very well with a visual method *(2)* based upon dilution and comparison with a color standard.

In 1957 Moster and Prater *(4, 5, 6)* published a series of papers dealing with the extraction of the coloring matter in paprika and evaluation of the coloring matter on the basis of an absorbance measurement at 470 millimicrons. The absorbancy is substituted in an equation designed to convert the reading to a color value that would correspond to those by the visual method *(2)* using potassium dichromate-cobaltous chloride solution.

The authors believe the coloring matter in capsicum spices and oleoresins of paprika can be evaluated more accurately with different instruments in different laboratories if the instruments are calibrated with a pure compound such as beta-carotene (which has color characteristics very similar to the coloring matter in capsicum and paprika, Figure 1), and the color in the samples is expressed as equivalent to micrograms of beta-carotene per gram of sample. This technique has been applied to the evaluation of egg color *(1, 9)*.

PROCEDURE AND RESULTS

In applying this technique to capsicum spices and oleoresins of paprika the size of sample to be extracted with acetone and the dilution to be made is selected and fixed for each type of

sample (such as paprika, oleoresin of capsicum, etc.) so that the absorbancy measurements will be between 0.1 and 0.8, preferably in the middle of the range. Typical results using a Coleman model 6B spectrophotometer and a Bausch and Lomb Spectronic "20" are given in Table 1.

TABLE 1

Absorbancy of test solutions and color expressed as micrograms of carotene per gram of sample of paprika

Sample number	1	2	3	4	5
Absorbancy at 460 mmc using Coleman Model 6B	0.602	0.432	0.403	0.342	0.146
B&L Spectronic "20"	0.680	0.471	0.432	0.364	0.142
Mcg of beta-carotene per gram of sample using Coleman Model 6B	4040	2800	2620	2220	940
B&L Spectronic "20"	4060	2850	2640	2180	860

The precision of this method was investigated using two B&L Spectronic "20's" and two Coleman Model 6B's. Two analysts ran each of 5 samples of paprika powder in duplicate with each instrument. A calibration curve was developed for each instrument. An analysis of variance was performed for each sample. The results are tabulated in Table 2.

Excellent results were obtained with the method. The data indicate that it is suitable for evaluating the color of paprika and products with similar color characteristics.

Analyses of 2 identical samples of paprika in 3 laboratories using different instruments are given in Table 3. All of the results were within 5% of the average. This is considered very satisfactory for analyses which involve extraction of the coloring matter and measurement of absorbancy.

EVALUATION OF CHLOROPHYLL CONTENT

The relative amount of chlorophyll in a sample can be determined from the difference in absorbancies measured at 630 and 670 mmc on the concentrated extracts before dilution *(1)*. The establishment of the technique and terms for expressing chlorophyll can be worked out easily when it becomes necessary to indicate the relative amount of chlorophyll.

Method

A. Reagents:

1. Acetone, A.C.S. grade.
2. Potassium dichromate, reagent grade.
3. Beta-Carotene, 100%, Eastman Kodak No. 3702 or equivalent. A calibration graph should be prepared as soon as possible, after a fresh supply of carotene is received. Carotene is unstable, but it can be kept for several months without significant change if stored in sealed tubes and kept in a refrigerator.
4. Carbon tetrachloride, reagent grade.

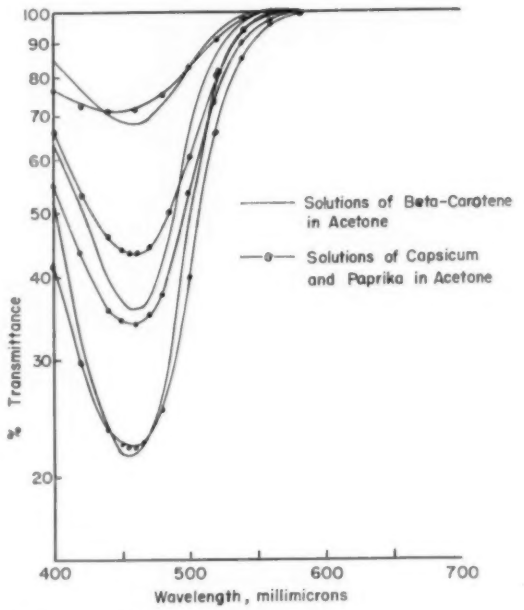

Figure 1. Color characteristics of beta carotene vs those of capsicum and paprika.

TABLE 3

Micrograms of beta-carotene per gram of paprika sample as determined in different laboratories

Laboratory	Instrument	Cuvette I.D.	Micrograms carotene per gram sample	
			A	B
A	B&L Spectronic "20"	10 mm	3400	3480
B	B&L Spectronic "20"	19 mm	3600	3380
C	Coleman Model 6B	19 mm	3660	3640
D	Coleman Model 6B	19 mm	3600	3440
	Average		3520	

B. Standard Color Solutions:

1. Carotene solutions. These solutions must be prepared the same day the instrument is calibrated and in their preparation, carotene from a freshly opened tube must be used.

(a) Standard Carotene Solution:

Weigh exactly 0.1000 g of carotene into a 150-ml beaker. Add 5 ml of carbon tetrachloride and stir with a glass rod to dissolve the carotene. Add ca 70 ml of acetone, stir, allow to stand 1 or 2 min and and decant the solution into a 1000-ml volumetric

TABLE 2

Variance components for different samples

Source of variation	Sample					
	1	2	3	4	5	Av
Type of spectrophotometer	354	0	0	0	3,738	818
Instruments within types	0	0	1,640	1,038	1,438	823
Analysts within instruments	1,233	3,336	2,575	1,425	3,550	2,424
Duplicates within analyst	3,725	1,200	375	800	3,475	1,915
Total	5,312	4,536	4,592	3,263	12,201	5,981
Mean color	3,289	1,332	2,886	3,525	4,404	3,087
Coefficients of variation	2.2	5.1	2.3	1.6	2.5	2.5
95% probability limits for difference between results by analysts using different types of spectrophotometers	206	191	198	162	312	218

flask, retaining any undissolved carotene in the beaker. Treat any undissolved carotene as before and repeat until carotene is completely dissolved and transferred to the volumetric flask. Dilute to mark with acetone and mix thoroughly. One ml of this soln contains 100 meg of carotene.

(b) Diluted Carotene Solutions:
Pipet 0.5, 1.0, 2.0, 3.0, 4.0, and 5.0 ml of the Standard Carotene soln into a series of 100-ml volumetric flasks. Dilute to mark with acetone and mix thoroughly. The diluted solns contain 50, 100, 200, 300, 400, and 500 meg of carotene per 100 ml of soln.

2. Standard Potassium Dichromate Solutions:

(a) Weigh the specified amount of potassium dichromate to the nearest milligram and transfer quantitatively to 1000 ml volumetric flasks.

Amount to weigh, g	Concentration of soln. %
0.100	0.01
0.200	0.02
0.300	0.03
0.400	0.04
0.500	0.05

Dissolve in ca 500-ml of distilled water, dilute to mark and mix thoroughly.

C. Calibration:

1. Measure transmittance of the diluted carotene solns at 455 mme with spectrophotometer or filter photometer set to read 0% transmittance when no light reaches the photocell and 100% transmittance (zero absorbancy) when an absorption cell is filled with acetone.
Note: The authors used a B&L Spectronic "20" and 19 x 105 mm round cuvettes.

2. Plot on regular graph paper the absorbancy of each soln against the micrograms of carotene in 100 ml of soln. Draw a smooth curve from zero absorbancy through the points. Do not use or plot absorbancy values above 1.0.

3. Measure the absorbancy of each of potassium dichromate solns at the same time and under exactly the same conditions.

4. Record the absorbancy values of potassium dichromate solns. Select solns with absorbancy values between 0.2 and 0.6 for routine checking of the instrument.

D. Checking Instrument:

1. Measure the transmittance of one or more of the selected potassium dichromate solns each day tests are made. The instrument is in proper adjustment as long as these measurements check those made at the time of calibration within the limits established for the instrument. When measurements made on the dichromate solution are outside acceptable limits, repeat calibration using carotene and potassium dichromate solutions.

E. Procedure:

1. Weigh size sample indicated and transfer quantitatively to a 200-ml volumetric flask.

	Weight of sample g
Paprika	2.00 ± 0.01
Oleoresin of capsicum	1.00 ± 0.005

2. Make up to volume with acetone and mix thoroughly.

3. For samples like paprika allow to stand 24 hr at room temperature and away from strong light. Mix several times during this period by inverting the flask several times for each mixing. For samples like oleoresin of capsicum proceed with color measurements as soon as sample is dissolved.

4. Allow suspended matter to settle, if present. Pipet and dilute as indicated below:

	Ml to be pipetted	Volumetric flask to be used
Paprika	10	200 ml
Oleoresin of capsicum	10	200 ml

5. Make up to volume with acetone and mix thoroughly.

6. Transfer a suitable portion of the acetone solution to the same type of clean dry absorption cell used for calibrating the instrument and measure the absorbancy against acetone.

7. Record the absorbancy and read the carotene content per 100 ml of solution.

F. Calculations:

$$\text{Color, in micrograms of carotene per gram of sample} = \frac{A}{B}$$

A = micrograms of carotene per 100 ml of solution read from calibration graph, E. 7.

B = grams of sample in 100 ml of solution on which absorbancy is measured in E. 7.

SUMMARY

A spectrophotometric method has been proposed for evaluating the coloring matter of paprika, oleoresin of capsicum and similar products. Better agreement among laboratories is expected by this method as the instruments are calibrated using the pure beta-carotene and the color is expressed as micrograms of carotene per gram of sample.

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Gas Chromatography As a Means of Detecting Odors in Milk*

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Department of Dairy, Food Technology Program, Michigan Agricultural Experiment Station, East Lansing

(Manuscript received December 2, 1959)

JUDGES OF DAIRY PRODUCTS use the senses of smell and taste effectively in evaluating the organoleptic quality of milk and its derivatives. Through practice in detecting and identifying off flavors in dairy products, they develop an acuity which, to the inexperienced, is little short of phenomenal.

Judging proficiency is recognized and relied upon in all dairy food flavor studies. Despite the keen sensitivity of the nostril to detect minute traces of odoriferous substances, in some cases as dilute as a few parts per billion, the quantitative evaluation of the sensory reaction does vary among judges. Consequently, any objective measurement of odor is looked upon with favor.

The advent of gas chromatography stimulated food research workers toward further objective studies in flavor evaluation. The studies reported herein resulted from trials to find out to what extent gas chromatography could be used routinely in odor identification and evaluation of specific and mixed milk.

Feed flavors remain a problem. Much has been done during the past 25 years to improve the flavor qualities of beverage milk in the United States. Yet, feed flavors continue to be the most common flavor defect of milk. Attempts to safeguard the milk supply against these flavors by correcting feeding practices and herd management have not been too successful. Withholding feed until after milking, providing good barn ventilation, and taking cows off feed flavor-bearing pastures 5 hours before milking were sound practices but were not always readily accepted by the milk producer.

Butter manufacturers turned to high-temperature, vacuum treatment as a practical means of removing the troublesome feed flavors from the cream prior to churning. The successful achievement of this goal, however, depended upon a knowledge of the nature of the flavor component being removed from the cream and adjusting the intensity of the treatment to effect its removal *(4, 5, 6, 7)*.

More recently, processors have subjected whole milk to varying conditions of vacuum and/or vacuum-heat treatments for the purpose of removing the objectionable feed-associated flavors. In those milk producing sections where wild onions are a common spring and fall pasture pest, vacuum heat treatment of the milk has become popular. Not only were most of the objectionable feed flavors removed from the milk or satisfactorily reduced in intensity, but a standardization of the flavor was obtained as well.

Such flavor removal equipment furnished an opportunity to study (a) the degree of effectiveness of odor removal, (b) the nature of the odoriferous substances removed, and (c) the sensitivity of gas chromatography as a tool for measuring the normal feed odors of milk.

EXPERIMENTAL

Volatile components were collected from (a) raw, bulk mixed milk obtained from producers supplies, (b) the same milk during vacuum-heat processing, and (c) the finished product.

In other trials, known, induced feed flavors were obtained by feeding a cow on successive days, 2 hr prior to milking, alfalfa silage, beet tops and onion tops as the trials dictated. The milk was collected in a 12-liter, round-bottom flask, stoppered and taken immediately to the laboratory where the volatiles were collected and resolved by gas chromatography.

A low-temperature, reduced-pressure, collecting system, similar to the apparatus employed by Day *et al. (1, 2)*, was used to trap the volatile materials from the various milk samples and from the vacuum line of the processing unit. The volatile collection schemes are illustrated in Figure 1.

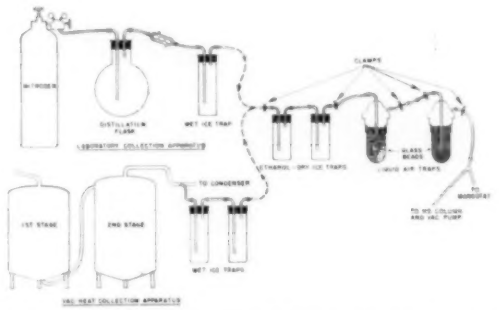

Figure 1. Schematic diagram of the apparatus used to collect volatile materials from the laboratory and vacuum-pasteurization deodorizing units.

The procedure used with the small samples of milk consisted in distilling the volatile materials under one-inch vacuum at 50° C. Nitrogen gas was bubbled through the milk to displace the air in the system and, when the temperature was raised, to assist in the entrainment of the volatile flavor materials from the milk to the traps.

Dow-Corning Antifoam AF was used to suppress foaming of the milk. Volatile substances from the distillation were fractionated by passing through a stepwise trapping system maintained at three different temperatures namely, 0° to 5° C (ice water), −60° C (dry ice and alcohol), and −185° C (liquid air). The traps in the liquid air bath were filled with glass beads to provide a maximum condensing surface for the entering volatiles.

* Michigan Agricultural Experiment Station Journal Article No. 2541.

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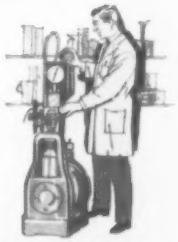

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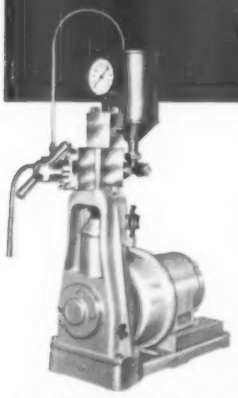

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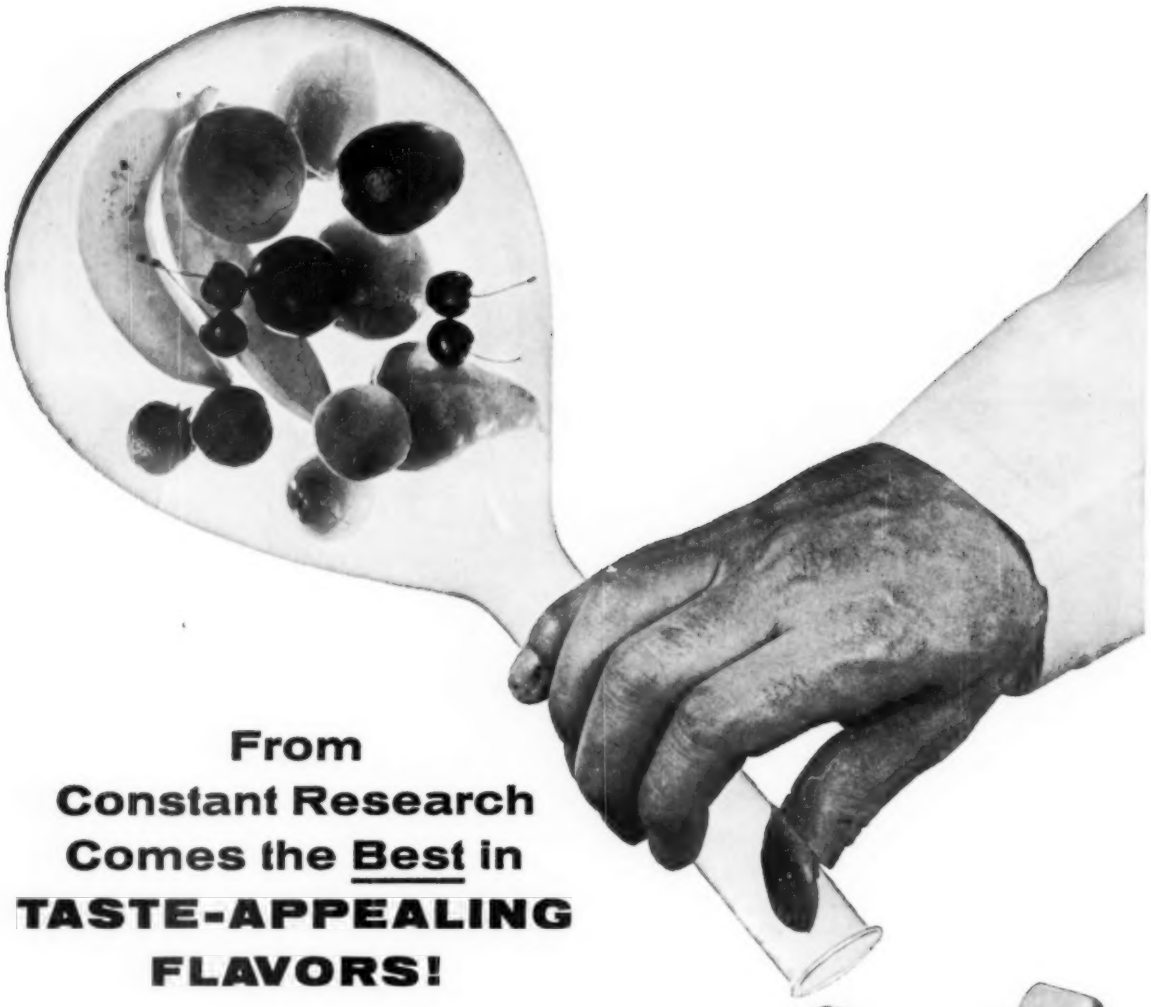

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The collection of the volatile substances from the vacuum-heat processing unit was accomplished with the same trapping device as previously described. Vapors were withdrawn from the vacuum line immediately preceding the vapor condenser. A second ice-water trap was required to remove the large amount of water condensate constituting the vapor phase. A vacuum of one to two inches of mercury above that maintained in the processing unit ($\simeq$18") was required to drain the vapor through the trapping system.

In removing the volatile substances, both from the mixed and from the individual cow milk, the bulk of the water condensate was collected in the ice-water trap. The residual moisture passing the first trap was caught in the dry ice alcohol trap. Small quantities of the aromatic volatiles were caught here also, as was indicated by the odors present in the trap following warming.

Most of the aromatic volatile materials were condensed in the first liquid air trap. The small amount of aromatic volatile material collected in the dry ice traps was transferred to the liquid air trap by removing the refrigerant and allowing the volatiles to distill into the colder trap as the temperature was raised to 50° C.

The condensate, which formed in the ice-water trap, was saturated with NaCl and extracted with diethyl ether according to the techniques of Jackson and Hussong *(3)*. No appreciable amount of flavor volatiles were recovered by this method from the condensate. A representative portion of the more highly volatile substances was concentrated in the liquid air trap. A three-hour collection period provided sufficient quantity of volatile materials for subsequent analyses by gas chromatography.

Analysis of the volatile substances. A Perkin-Elmer Model 154-B Vapor Fractometer, employing thermistorized thermal conductivity sensing cells was utilized in this study. A gas sampling valve was modified to permit the introduction of the sample directly from the liquid air trap. The cold finger, containing the condensed volatiles, was transferred, while still at liquid air temperatures, to the gas-sampling attachment on the Fractometer. Helium gas, the carrier gas used for the fractionation, was passed through the cold finger to displace other gases. The system was closed and the condensed substances volatilized by surrounding the cold finger with oil at 100° C.

Following a tempering period of approximately 15 minutes, the vapor was sampled directly into the helium stream passing through the fractometer. Gas chromatograms of the various components, comprising the volatile mixture, were recorded.

A tentative identification of the resolved components was made by comparing the retention times and/or volumes of the various components with those of authentic compounds and by introduction of the authentic components into the sample as internal standards.

Three different immobile phase columns, (a) acid washed Celite 545 (30–60 mesh) mixed with 20% (w/w) dioctylphthalate, (b) didecylphthalate, and (c) "Carbowax 400", were employed. All columns were flushed with helium gas for 7 hr at 50° to 70° C prior to use.

Olfactory observations to detect the presence of odor were made in each of the condensing traps following a collection of volatiles. The milk was scored for flavor by at least 3 persons prior to and following the vacuum heat treatment. Normally, milk is scored for flavor as follows: *excellent* (40); *good* (37.5–39.5); *fair* (32.0–34.5); and *poor* (32.0–34.5). Feed flavor criticisms range from strong (37) to slight (39). One-to-two points represent a significant change in flavor.

RESULTS

Resolution sensitivity of the chromatographic columns. A known mixture consisting of equal volumes of acetone, acetaldehyde, and methyl sulfide, compounds known to contribute to the normal flavor of milk, was employed as a test standard for selection of the column liquid phase. Of the three liquid phases tried, dioctylphthalate was the most efficient in resolving the mixture. Similarly, the dioctylphthalate column gave the most satisfactory resolution of the volatile fraction collected from raw milk and was used routinely in this study.

Removal of odors from mixed herd milk by vacuum heating. Removal of odors from bulk mixed herd milk by vacuum pasteurization appeared to be quite effective (Figure 2). The chromatograms *A* and *C* show the "before" and "after" patterns of volatility as a result of vacuum heat treatment. The volatiles for these two chromatograms were collected by identical procedures. The differences in peak areas are construed, therefore, to represent the reduction in intensities of volatiles resulting from vacuum-heat processing. The reduction amounted to approximately 85%. The *B* chromatogram represents a qualitative analysis of the volatile fraction collected from the deodorizing equipment.

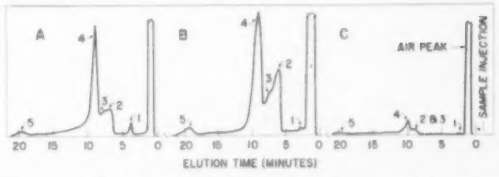

Figure 2. Gas chromatograms of volatile materials collected from: (A) Raw milk prior to vacuum pasteurization. (B) Vacuum chamber of the processing units. (C) Vacuum processed milk. Column, dioctylphthalate; temperature, 75° C; He flow, 44 ml/min. Peaks 1–5 were identified as acetaldehyde, methyl sulfide, acetone, unidentified carbonyl compound, and water, respectively.

The retention volumes of peaks 1, 2, and 3 were approximately equal to those for acetaldehyde, methyl sulfide, and acetone, respectively. An additional qualitative identification of these peaks was achieved by the incorporation of authentic compounds as internal standards. Peak 4 was not identified, but the contributing volatile substance produced hydrazones when passed through an acidified solution of 2, 4-dinitrophenylhydrazine as did the components constituting peaks 1 and 3. Peak 5 appeared to be one for water although positive identification was not made. Carbon dioxide was presumed to constitute the major portion of the large initial peak (air). The temperature in the liquid air trap is low enough to collect carbon dioxide expelled from the milk. Further, a fine white precipitate was noted when the eluate constituting this peak was passed through lime water.

The qualitative nature of the materials removed from the raw milk by the relatively mild treatment employed in the laboratory collection apparatus was similar to the volatiles removed by the more intense steam injection vacuum treatment employed in the commercial unit. The primary and important difference being the rate at which the volatile materials were removed being far greater in the commercial unit per pound of milk treated. In all instances where "feedy" or "cowy" was the flavor criticism, the flavor score was improved from one-to-two points by the deodorizing treatment.

Removal of odors from individual cow milk by vacuum treatment. The odoriferous substances of milk from cows fed alfalfa silage, onion tops, and beet tops 2 hrs prior to milking were readily removed from the milk by nitrogen-vacuum entrainment employed in the lab-scale collection scheme. The gas chromatograms of these collected materials are shown in Figure 3. No attempt was made to identify the compounds resolved

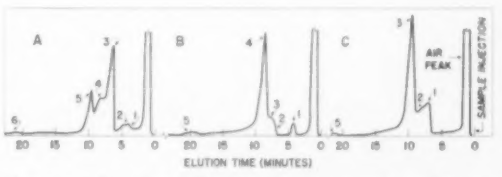

Figure 3. Gas chromatograms of the volatile materials collected from the milk of individual cows fed (A) alfalfa silage, (B) onion tops, and (C) beet tops two hours prior to milking. Column dioctylphthalate; temperature, 75° C; He flow, 44 ml/min. Components corresponding to peak numbers were not identified.

on the chromatograms. It seemed apparent that the various milks contained volatile flavor components in varying proportions as well as specific components characteristic of the feed given the animal.

DISCUSSION

These observations offer an opportunity for making some interesting conjectures relative to the deodorization of milk on a commercial scale. The chemical and physical properties of the materials being removed constitute a primary consideration. Substances which are easily detected in the head space of a closed container are, no doubt, volatile enough to be removed by relatively simple procedures, such as vacuum flashing. Most of the flavor substances encountered in a milk supply criticized as "feedy" or "cowy" are of this category. On the other hand, substances which are less volatile require more drastic treatments to liberate them from the milk. In this case flashing from high temperatures, above 190° F, to a lower temperature zone of 165° to 160° F would be more effective in off-flavor removal.

Possibly some of these volatile materials so readily removed from the milk by deodorizing equipment contribute to the natural, blended flavor of fluid milk. Removing them could render the product bland and tasteless. In practice, a slight cooked flavor results from the high-temperature processing which seems not to be objectionable to the consumer and serves to substitute for the natural flavor removed by the vacuum pasteurization process.

Although gas chromatography offers a promising approach to studying the flavor components of milk, refinements in the technique will have to be made before many of these components can be positively identified or even detected. A new innovation in detecting devices—namely, the ionization detector—integrated with capillary columns seems to offer this opportunity. The sensitivity and resolving power of these new units have been increased many thousand fold; possibly, even approaching the threshold of some organoleptic sensitivities.

Future approaches in this field should be to determine the nature of the deodorizing treatment required to remove the various flavor components and to determine which of these components or groups of components contributes to the enhanced flavor of milk and which are detrimental to the flavor of milk. When such information is available, we should be able to control the physical parameters of the deodorizing process, utilizing gas chromatography as a quality control instrument. Conceivably, the conditions of this treatment would vary from location to location and from season to season.

SUMMARY

Gas chromatography was utilized to show the effectiveness of vacuum pasteurization as a means for removing the volatile feed flavors from milk. Approximately 85% of the measurable flavor components of milk were removed by the vacuum pasteurization process with a resulting one-to-two point increase in flavor score.

Characteristic gas chromatograms were obtained for the volatiles in milk from cows fed alfalfa silage, onion tops, or beet tops.

Gas chromatography offers a valuable tool for the study of the effectiveness of deodorizing equipment as a means of removing the volatile flavor components of milk.

Acknowledgment

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The Preservation of Fish with Ionizing Radiation: Bacterial Studies*

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ONE OF THE possible peaceful uses of atomic energy is to utilize gamma radiation for sterilizing and preserving food. Numerous investigators have shown that gamma radiation is effective in destroying most food spoilage organisms, but chemical alteration of the food also occurs, affecting its organoleptic acceptability. The extent of both bacterial destruction and alteration is dependent on the amount of radiation used and also varies with the organisms involved and the character of the food product.

The present study was undertaken to determine the effects of ionizing radiation at various levels on the bacterial flora of fillets of Pacific cod *(Gadus macrocephalus)* during storage in melting ice (0° C).

The principal objectives were:

1. To compare bacterial counts of unirradiated and irradiated fillets.
2. To identify bacterial genera present before and after irradiation and during storage.
3. To estimate relative numbers of bacteria generically at various levels of irradiation and intervals of storage.
4. An incidental study of micrococci present to assess their potential as food poisoning organisms.

EXPERIMENTAL PROCEDURES

Sample preparation. Fillets for these experiments were prepared from fresh cod by normal production procedures at a commercial fish packing company. Fillets were washed with cold water, drained, cut into 2½ in circles, packed in No. ½ flat C-enamelled salmon cans, and sealed without vacuum. Each can contained 2 to 3 pieces of fillet from as many different fish. Shipment to and from the radiation source, the Materials Testing Reactor, Idaho Falls, Idaho, was made in a wet ice shipping container via air freight. Three days elapsed between shipment and return receipt of samples. Three shipments were made during the course of these experiments, and data will be presented on findings within these 3 shipments. Radiation levels in the experiments were as follows:

I. 0 (control), 0.07, 0.14, 0.23, and 0.46 megarad.
II. 0 (control) and 0.2 megarad.
III. 0 (control), 0.5, 1.0, and 2.0 megarads.

Bacteriological technique. At each sampling 33 g of fillet in approximately equal proportion from the 2 or 3 pieces in each can were cut, using sterile scissors, and transferred to a sterile stainless steel or aluminum Waring blender jar; 297 ml of sterile water (three 99 ml water blanks) were added and the sample was blended for 2 min. Dilutions were made in blanks of sterile 0.1% peptone *(13)*. In Experiment I cans from each radiation level were selected and plating was done using duplicate plates of tryptone-glucose-yeast extract agar (TGY) which Anderson *et al. (1)* used in studies on radiation resistant organisms in ground beef. In Experiment II, irradiated at a single level (0.2 megarad), 5 cans at each sampling were selected and the medium of Anderson (TGY) was compared with the same medium prepared with the artificial sea water base (TGYS) of MacLeod, Onofrey, and Norris *(9)*. No significant differences were noted between counts obtained with the 2 media and therefore only those obtained with the TGY medium are herein reported. In Experiment III only TGY was used and 5 cans from each radiation level were selected at each sampling.

In isolation studies, colonies were selected on the basis of colony characteristics with source and frequency of each isolate being noted. Identifications were carried out using Skerman's *Mechanical Key for the Generic Identification of Bacteria (11)* and standard techniques as outlined in *Manual of Methods of Pure Culture Study of Bacteria (12)*. Bergey's Manual *(3)* and the work of Zobell and Upham *(14)* were of auxiliary use.

For detection of possible "food poisoning" type micrococci, those isolates which grew in Difco brain heart infusion at 32° C within 24 hr were selected. Difco desiccated coagulase plasma and fresh human plasma were used to test for coagulase production. Tryptone-beef-extract-NaCl agar base to which was added whole citrated human blood in 5% concentration was used for both pour and streak plates to test for alpha hemolysin production.

RESULTS AND DISCUSSION

Population studies. Table 1 presents bacterial counts for both control (unirradiated) and irradiated samples in Experiment I.

The bacterial counts of control (unirradiated) and irradiated samples over the 5-week period do not entirely display a progression with time, indicating variation in initial counts from can to can. In controls and samples exposed to low level radiation, numbers of organisms in the particular sample probably determine differences in subsequent counts. In samples exposed to higher levels of radiation, growth characteristics of populations may be more dependent on the specific character of surviving organisms since the most radio-resistant species will predominate in these samples. This observation is supported in Figure 1 by differences between the character of the curves at the two lower levels (0.07 and 0.14 megarad) and at 0.23 megarad.

The two higher levels of 0.23 and 0.46 megarad show promise of practical application extending the storage life at 0° C to or beyond the 5-week period. However, correlation with organoleptic and chemical observations is necessary for validation of this conclusion which is based purely on bacteriological evidence. Organoleptic evaluation of control and irradiated samples from this study was independently conducted at the Seattle Technological Laboratory, Bureau of Commercial Fisheries, U. S. Fish and Wildlife Service. Findings of this work will be separately reported *(10)*.

* Performed under Contract No. 14-19-008-9322 for the U. S. Dept. of Interior, Fish and Wildlife Service, Fishery Technological Laboratory, Seattle, Washington.

TABLE 1

Experiment I. Average of duplicate bacteral counts on control (unirradiated) and irradiated cod fish fillets stored at 0° C

Exposure in megarads	Time after irradiation					
	0 week	1 week	2 weeks	3 weeks	4 weeks	5 weeks
	Bacteria per gram	*Bacteria per gram*	*Bacteria per gram*	*Bacteria per gram*	*Bacteria per gram*	*Bacteria per gram*
None	710,000	12 x 10^6	108 x 10^6	81 x 10^6	320 x 10^6	Not done
(Controls)	220,000	14 x 10^6	139 x 10^6	170 x 10^6	135 x 10^6	Not done
0.07	4,200	135,000	10 x 10^6	65 x 10^6	350 x 10^6	Not done
0.14	420	21,800	3 x 10^6	15 x 10^6	1.5 x 10^6	180 x 10^6
0.23	110	14,000	22,000	135,000	82,000	100 x 10^6
0.46	20	10	10	10	Lost	8,000

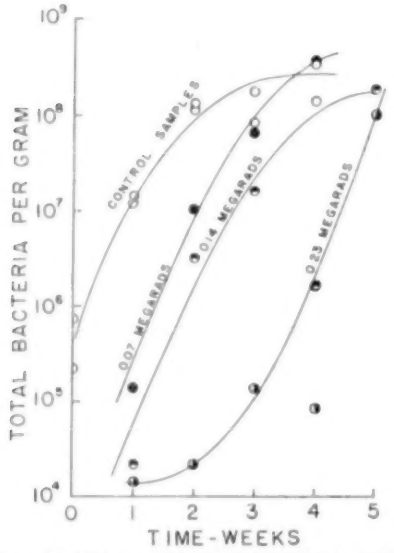

Figure 1. Bacterial growth rates in control (unirradiated) and irradiated cod fish fillet samples stored at 0° C. Experiment I.

In Table 2 total bacteria counts obtained in Experiment II are presented. These in general confirm results obtained in Experiment I showing pronounced retardation of growth at the 0.2 megarad level. In addition the extent of variation in counts from can to can is indicated.

In Table 3 comparative bacterial counts are shown on samples from Experiment III irradiated at 0, 0.5, 1.0, and 2.0 megarads and stored for 0, 1, 2, 3, 4, and 5 months. The table emphasizes the previous observation that number or organisms in individual cans is an important factor influencing the numbers found after subsequent storage intervals.

The very pronounced difference between results obtained at 0.5 megarad, and 1.0 and higher levels of radiation where counts remained quite low over the entire storage period, suggests a rather sharply defined tolerance limit for most organisms between 0.5 and 1.0 megarad.

The very large differences in counts observed between replicate cans is presumably due to the fact that fish were caught, transported and filleted under *commercial* conditions with attendant variable surface contamination.

Survey of flora. The predominant genera of bacteria found in fish have been reported by previous investigators. Some differences in their findings occur, e.g. the study of Dyer *(7)* on Atlantic cod showed *Micrococcus* predominant, making up 74% of the population. A British source *(2)* reported *Achromobacter* and *Pseudomonas* as making up 90% of the flora of cod. A recent study of the flora of Pacific fish by Liston *(8)* found *Pseudomonas* and *Achromobacter* predominant with Gram positive bacteria constituting only a small part of the flora.

Castell and Anderson *(5)* and Castell, Anderson, and Pinnick *(6)* showed that *Pseudomonas, Achromobacter, Serratia* (some), and *Proteus* produced the most offensive odors, while *Micrococcus* and *Flavobacterium* produced less offensive odors more slowly.

Only one reference in regard to the presence of anaerobes in the flesh of fish was found *(4)*.

Experiment I. *Pseudomonas* and *Achromobacter*, the genera closely associated with terminal malodorous spoilage of fish, appear to have been virtually eliminated at comparatively low levels of gamma irradiation. Of 85 organisms picked from plates as

TABLE 2

Experiment II. Bacterial counts on control (unirradiated) and irradiated (0.2 megarad) cod fish fillets stored at 0° C

	Time after irradiation				
	0 days	2 days	14 days	28 days	56 days
	Bacteria per gram	*Bacteria per gram*	*Bacteria per gram*	*Bacteria per gram*	*Bacteria per gram*
Unirradiated controls	300,000[1]	140,000	18,000,000	Spoiled	Spoiled
	310,000	210,000	23,000,000		
	650,000	1,700,000	30,000,000		
	670,000	1,800,000	34,000,000		
	700,000	6,000,000	39,000,000		
Irradiated with 0.2 megarad					
		700	13,000	1,400	21,000,000
		1,100	73,000	7,500	27,000,000
		1,200	77,000	14,000	200,000,000
		3,600	120,000	160,000	270,000,000
		9,200	380,000	4,000,000	830,000,000

[1] Bacterial counts were determined on 5 cans per treatment at each time of sampling.

TABLE 3

Experiment III. Bacterial counts on irradiated cod fish fillets stored at 0° C[1]

	Time after irradiation					
	0 month	1 month	2 months	3 months	4 months	5 months
Irradiated with 0.5 mega rad	*Bacteria per gram*	*Bacteria per gram*	*Bacteria per gram*	*Bacteria per gram*	*Bacteria per gram*	*Bacteria per gram*
	15[2]	30	5	1,000	3,000	10,000
	30	225	10	1,000	12,500	10,000
	35	280	50	17,000	375,000	20,000
	45	7,500	1,700	15,000,000	4,400,000	40,000
	120	350,000	5,600	30,000,000	6,500,000	75,000
Irradiated with 1.0 megarad						
	0	5	5	10	0	10
	5	5	10	10	10	10
	5	45	15	10	10	10
	5	115	20	15	10	25
	10	515	20	15	35	1,040
Irradiated with 2.0 megarads						
	0	0	5	10	0	10
	5	0	10	10	0	160
	10	0	10	10	30	210
	30	5	15	10	250	250
	40	10	15	115	310	660

[1] Unirradiated control samples were run only immediately after the irradiation date (0 month) due to rapid deterioration of the samples. Results from 5 samples (average of duplicate counts on each sample) were as follows: 4.8, 21, 28, 30, and 33 x 10^6.

[2] Numbers tabulated are averages of duplicate plate counts on single cans. Bacterial counts were determined on 5 cans per treatment at each time of sampling.

predominant colony types from irradiated samples, *Achromobacter* occurred in only one sample (0.14 megarad) and *Pseudomonas* appeared 5 times at 0.07 megarad but was found in only 2 samples of the 54 cans which had been exposed to 0.14–0.46 megarad.

The predominant genera of the controls were *Flavobacterium*, *Micrococcus*, *Pseudomonas*, and *Achromobacter* with smaller number of *Corynebacterium*. Also in order of predominance, genera of irradiated samples were *Micrococcus*, *Pseudomonas*, *Sarcina*, and *Corynebacterium* with a minor group composed of *Bacillus*, yeast *(Torulopsis)*, and *Mycoplana*.

Experiment II. Tables 4 and 5 summarize the floral study in which 138 cultures from controls and 183 from samples irradiated at 0.2 megarad representing all colony types were identified. It is to be noted that pigmented *Pseudomonas* was not found in this experiment. Possibly some non-pigmented *Pseudomonas* organisms were included with *Achromobacter*. In irradiated samples, *Achromobacter*, while at one time comprising 23.8% of the total population, subsequently was overgrown by *Micrococcus* and *Corynebacterium*. In this experiment, attempts to detect obligate anaerobes were negative.

Experiment III. After exposure to higher levels of irradiation (0.5, 1.0, and 2.0 megarads) 171 isolates revealed the presence, in order of probable predominance, of the following microorganisms: *Micrococcus*, *Corynebacterium*, *Sarcina*, *Alcaligenes*, *Flavobacterium*, *Achromobacter*, *Bacillus*, *Pseudomonas*, *Bacterium*, *Mycoplana*, *Actinomyces*, *Lactobacillus*, *Protaminobacter*, and *Streptococcus*. As far as is known *Bacterium* and *Protaminobacter* have not been reported as occurring in fish, but some *Bacterium* species have been classified as having a marine origin *(14)*. In this regard the *commercial* source of fish studied may explain the occurrence of unusual genera.

TABLE 4

Experiment II. Bacterial population of control samples (five per sampling)

Genus	Time after irradiation		
	0 days	2 days	2 weeks
	Estimated % of population		
Micrococcus	60.7	77.5	1.1
Achromobacter	16.0	5.1	67.0
Flavobacterium	10.0	0.5	11.6
Corynebacterium	1.3	9.7	13.4
Sarcina	2.7	0.0	1.1
Alcaligenes	4.3	0.5	0.0
Mycoplana	2.2	0.2	0.0
Streptococcus	0.4	0.0	0.0
Protaminobacter	1.3	0.2	0.7
Bacillus	0.4	2.0	0.0
Aerobacter	0.0	0.0	1.1
Yeast	0.4	4.8	4.0

TABLE 5

Experiment II. Bacterial population of samples irradiated at 0.2 megarads (five cans per sampling)

Genus	Time after irradiation			
	2 days	2 weeks	4 weeks	8 weeks
	Estimated % of population			
Micrococcus	76.6	70.9	87.9	39.5
Achromobacter	0.0	23.8	10.0	1.3
Flavobacterium	0.6	3.1	0.02	<0.1
Corynebacterium	1.2	0.0	1.7	56.6
Sarcina	21.8	1.7	0.005	0.0
Alcaligenes	0.0	0.2	0.9	0.0
Bacillus	0.0	0.0	0.0	1.6
Yeast	0.6	0.3	0.02	0.9

Study of micrococci. Of 61 cultures of *Micrococcus* tested for coagulase, three were slow positive in Difco desiccated coagulase plasma, all were negative in fresh human plasma, and none showed alpha hemolysin production. From these results it would appear that the micrococci found were probably not "enterotoxin" producing organisms and are not a probable source of the commonly called "staphylococcal" food poisoning even though the genus *Micrococcus* predominates.

SUMMARY

Irradiation of cod fillets at relatively low levels of gamma irradiation prolongs the bacteriological storage life at 0° C and appears particularly effective

against the genera usually associated with the production of offensive odors characteristic of typical spoilage. In unirradiated control samples the genera *Micrococcus*, *Achromobacter*, *Flavobacterium*, and *Corynebacterium* predominated while *Sarcina*, *Pseudomonas*, *Alcaligenes*, *Mycoplana*, *Protaminobacter*, *Bacillus*, yeast *(Torulopsis)*, *Aerobacter*, and *Streptococcus* were in minor numbers. Irradiated samples showed predominant genera to be *Micrococcus*, *Sarcina*, *Achromobacter*, *Flavobacterium*, and *Corynebacterium* while *Alcaligenes*, *Bacillus*, yeast *(Torulopsis)*, and *Mycoplana* were less numerous. Organisms of the genus *Micrococcus* appear to be resistant to radiation under conditions of these experiments. However the *Micrococcus* found do not appear to be typical food poisoning organisms.

Acknowledgment

The authors gratefully acknowledge the assistance of Mr. John Spinelli in the procurement and preparation of the fish samples.

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Notes and Letters

Frigi-Canning

There is evidence that a greater use of cold storage should and probably will be used in connection with canned foods. While canning has served admirably to provide seasonal succulent fruits and vegetables in all places at all times, there is room for improvements in quality—mainly in two categories, color and flavor.

The Blair *(1)* process, which alkalinizes peas with calcium and magnesium oxides, yields canned peas with the desired green color with no undesirable effects. But at ordinary temperatures the color relatively soon reverts to the usual olive green, making it impossible to distribute a standardized product over a reasonable period. The author has hand shelled peas carefully to avoid breaks in the skins where bacteria may be harbored, washed the peas with pre-sterilized water, filled them into sterilized jars, covered them with hot sterile brine (only the usual amount of salt) and given them a 10-minute process in boiling water with covers loose to permit air escape, then sealed the jars aseptically. The peas of course had the bright green color of blanched peas. But in a few months at room temperature the color was olive green comparable to that of ordinary canned peas.

Probably the most serious flavor problem is with canning evaporated milk. It has been shown with a great deal of research that it is possible to can evaporated milk without producing the usual characteristic flavor but within relatively short periods at ordinary temperatures the usual flavor of evaporated milk develops.

The freezing of concentrated orange juice was developed with the idea it would not need to be subjected to heat. But it was soon found that to inacti-

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vate enzymes which deteriorated quality as much heat is required as in canning unconcentrated orange juice in which all essences are retained and which, if held under refrigeration, makes possible a superior product. Its greater volume militates against its being distributed under refrigeration.

Short time, high temperature sterilizing processes with agitation of the can contents during processing have been developed for some vegetables with improved color and flavor. Guyer and Holmquist *(2)* have shown that while the process is adequate for peas to prevent bacteriological spoilage, enzyme regeneration, as evidenced by chemical tests, occurred within less than a month and at room temperatures off flavors developed within 8 months. Before the peas were canned they had been blanched 3 minutes at 190° F, which is as much as frozen peas usually get. Evidently the lower temperature prevents the regeneration of enzymes or their later effect.

Fruits and vegetables subjected to enough heat to inactivate all enzymes may be looked upon chemically as a mixture of many organic compounds, more or less complex. It is unreasonable to expect that there will be no interaction between them or that all will be stable. All such reactions are subject to the well established law that their rate is diminished by about half for every 18° F lowering of the temperature. This has also been established to hold for the interaction between the can and its contents.

A striking example of what a combination of heat and cold can accomplish is fresh milk. In its early history formaldehyde was used for its distribution. When legal steps prohibited the use of preservatives, some took it to be the doom of fresh milk distribution. Subsequent development of pasteurizing and refrigeration, neither one of which alone would be satisfactory, have made its delivery easy, and it can be held in a household refrigerator for a week or two with little deterioration.

In 1942 everyone was encouraged to take up gardening as a war measure. While gardening was not new to the author, he has been a more substantial gardener ever since. As every gardener knows, the surplus is always discomposing, particularly when food is at a premium. The thought occurred what a boon it would be if, by a relatively simple method, the surplus could be preserved for the off season. That is when Frigi-Canning was born. It is in reality merely an extension and perfection of what every householder does to a limited extent; namely, holds cooked food in the refrigerator for future use. It resembles commercial canning in that products are canned every day which would spoil if stored at higher than usual temperatures, as in the tropics.

EXPERIMENTAL

To convey an understanding as to what is meant by Frigi-Canning it is advisable to describe what has been done to develop it. Briefly, Frigi-Canning may be defined as the preservation of succulent foods by enough heat to kill vegetative micro-organisms, possibly thereby injuring surviving spores to discourage their germination, hermetically sealing under reasonably aseptic conditions and storing at the lowest possible temperature without freezing.

Since Frigi-Canning was developed in connection with home gardening, it was natural for the work to be done in the home kitchen. The equipment consisted of 2 fairly large aluminum kettles, one to hold upright 6 to 8 pint jars, another to cook enough vegetable to fill the jars. The products comprised the gamut of prepared garden vegetables.

The empty jars were held in boiling water. After cooking the vegetable 5 to 10 minutes in water barely sufficient to cover it while raw, a jar was lifted from the boiling water, filled with the proper proportion of cooking water and vegetable, immediately sealed and placed back in the kettle of boiling water holding the remaining empty jars. When all the jars were filled, or after a few minutes, the kettle holding them was placed in the sink and cold water was started running into it as fast as possible without cracking the glass. With a little stirring of the water to mix, modern glass permits a full stream of cold water within 2 minutes.

When as cold as practical, the jars were taken from the water and placed in the household refrigerator. The next day the material was taken to the village storage plant where a locker in the precooling room was provided. Since even at infrequent visits temperatures as high as 38° F were observed, no doubt the temperature at times went higher.

Limited opportunities permitted some little commercial experiments. In making baby soups, sweet potatoes are difficult to obtain for a considerable part of the year. Large sweet potatoes were cut into inch thick slices and cooked until soft. They were then filled into hot gallon glass jars and sealed. To sterilize the head space the filled and sealed jars were returned to the boiling water for 5 to 10 minutes. They were then cooled in cold running water and placed in a refrigerating room. This also received produce daily—milk, cream, parsley, etc. A few months later the entire 80 jars were opened, thoroughly inspected, found to be in perfect condition, and the contents were used in baby soups.

In Belgium 50 Kilo cans each of factory prepared cut beans and shelled (in a pea viner) beans were packed with factory equipment by the Frigi-Canning procedure. In this case also only the factory refrigerator which received raw produce daily was available. Five months after packing, all the cans were opened and examined. Two cans of shelled (haricot) beans were soft swells and the beans were sour. The cause of spoilage, whether due to leaky cans or too high storage temperature, is not known. All other cans of shelled beans and all cans of cut beans were in perfect condition and were used in vegetable soup.

DISCUSSION

In Belgium cut green beans and shelled (haricot) beans, referred to above, are packed in barrels with salt and brine to provide about 12% salt. They undergo more or less fermentation. When later carrots and turnips are available, these cut beans and shelled beans are boiled in large amounts of water two or three times to extract the salt and fermentation flavor. They are then used in packing ½ Kilo jars with 5 layers of vegetables, carrots, turnips, peas (canned) cut beans and shelled beans. It is a beautiful package, but it is a shame to have to use such low quality products as fermented, boiled out, cut beans and shelled beans, described above. It is an expensive package since each layer of vegetable is filled into the jar and pressed by hand with a tamper to keep the layers distinct and unmixed.

Incidentally, to indicate the low quality of the salt preserved products, the author was informed by the President of the Company, upon returning to Belgium after a month's absence that a couple of vegetables had to be left out of the vegetable soup which the author had developed because their flavor did not go well in it. In running down the source of this

puzzling information, it was found that the production manager had ordered the use of brine preserved cut beans and shelled beans in place of the canned items specified in the formula of the soup. He had not explained the facts fully to the President. This indicates the need for Frigi-Canned products for reprocessing purposes.

While the original thought of Frigi-Canning was in connection with preserving the surplus of home gardens, its commercial advantages are so self evident there need be only brief mention of a few. The color and flavor changes due to high temperature sterilization are avoided. Since the cooking water is preserved with the vegetable and blanching is not necessary to drive out the air, there is a great saving of nutrients. The thawing problem of frozen foods is avoided. Naturally, for commercial production, a continuous process must be developed but in a cannery this presents no difficulty.

In an hermetically sealed product consideration of *Clostridium botulinum* is imperative. This requirement has not been neglected. To quote Dr. Russel Esty as of 1943 *(3)*: "Regarding the lowest temperature at which botulinum spores will germinate, I discussed this with Dr. Meyer and he is very certain that the spores will not germinate at temperatures around 35 to 40° F. We do not know of any comprehensive study to show the lowest temperature at which the spores will germinate and vegetative forms multiply, but it is safe to assume that botulinus organisms and other anaerobic food spoilage organisms will not grow below 45° F and probably not below 50° F."

To quote Dr. K. F. Meyer as of 1958 *(4)*: "I wish to advise you that according to all recent information it is definitely established that for safety purposes 50° F and below can be considered to prevent the germination of *Cl. botulinum* spores. We have done no recent work, but these are the figures which are being constantly used. I would not entirely agree with Dr. Esty's statement that very little if any germination would occur at 55 to 60° F; this depends on the environment in which spores may find themselves; 50° F is the dividing line."

Ohye and Scott *(5)* have made a study of *Cl. botulinum*, type E, found in fish and in marine mud. To quote from their summary: "Ten strains of *Cl. botulinum*, type E, have been studied at 12 temperatures between 2.5 and 45° C. Growth proceeded consistently from spore inoculum at temperatures between 5 and 37.5° C." But only 6 of the 10 strains germinated at 5° C. To quote further: "The upper and lower temperature limits were several degrees lower than for type A and B strains." Ohye and Scott ascribe this to the lower temperature habitat of type E. They found the heat resistance of the spores to be only 1/1000th that of types A and B strains and one gathers from their paper that they interpret this to be about 10 minutes at 80° C. This would eliminate it from consideration in Frigi-Canning.

CONCLUSION

Originally consideration was only for the home gardener who, without canning equipment of any kind, but with some refrigeration space, could, by Frigi-Canning, do considerable to make use of his surplus. Also the city dweller on his week-end drive could pick up at low cost a hamper of his favorite vegetable and by this method enjoy it for a considerable time.

The favorable results that have been obtained indicate there may be a much more extensive possibility. Even now canned whole hams may be regarded as being Frigi-Canned. Originally there was strong opposition to freezing vegetables in hermetically sealed cans for fear they might be allowed to be held under conditions favorable to the development of *Cl. botulinum*. Now a wide variety of products that one would regard as excellent media for this organism are frozen in hermetically sealed cans. Consumer education is a part of any successful distribution. Even fresh milk, a good medium for *Cl. botulinum*, is distributed under poorer refrigeration than one would expect for Frigi-Canning. A canner serving large users, such as restaurants and hotels and reprocessing manufacturers, could easily observe and supervise the refrigeration of Frigi-Canned products. To be sure, anyone would be remiss and foolish not to give the matter *technical study under his own conditions before doing Frigi-Canning on a large scale*. This, I emphasize, is essential. Perhaps more heat than is herein indicated would be desirable. Every precaution, certainly, should be taken to avoid the risk of spoilage.

Edward F. Kohman
Kingshighway East
Merchantville, New Jersey

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5. Ohye, D. F., and Scott, A. J. Studies in the physiology of *Clostridium botulinum*, Type E. *Australian J. Biol. Sciences*, **10**, 85–94 (1957).

BONVENTRE, P. F. AND KEMPE, L. (Univ. of Michigan, Ann Arbor). *J. Bacteriol. 78*, 892–3 (1959).

The first successful attempts to increase the toxicity of botulinum toxin with proteolytic enzymes are reported for a type E strain of Clostridium botulinum. Attempts to activate types A and B toxins in the same manner were not successful.

Nutrition

Protein nutrition and enzyme changes in man.

WATERLOW, J. C. (Univ. of the West Indies, Jamaica). *Federation Proc. 18*, 1143–55 (1959).

The nature of the relation between enzyme activity and dietary protein intake is discussed. It is unlikely that measurement of any one enzyme or system in one tissue could be used as a general index of protein malnutrition, because, as deficiency progresses, the pattern of enzymatic activity in different organs must constantly be changing. However, measurement of appropriate enzymes in blood and digestive juices probably does give information about the protein synthetic or secretory activity of individual organs. It is possible that specific types of amino acid deficiency or imbalance in the diet might lead to characteristic tissue enzyme changes which would be diagnostic. So far, however, no example of such a relationship has been established.

Biologic availability of essential amino acids to human subjects. III. Whole egg and beef muscle.

WATTS, J. H., ALLEN, C. H. AND BOOKER, L. K. (Tuskegee Inst., Alabama). *J. Am. Dietetic Assoc. 36*, 42–5 (1960).

Two men and 3 women participated in an investigation to det. the availability of the 8 essential amino acids in diets contg. a large amt. of either whole egg or beef muscle. Availabilities for the egg diet were between 76 and 91% and for the beef diet, 80 and 93%. Neither diet showed a superiority over the other.

Potassium-lysine relationships.

ANON. *Nutrition Revs. 18*, 18–19 (1960).

The effect of altering potassium levels in diets contg. various levels of lysine was studied in the rat. Differences in hair loss and histological changes in the liver indicate a protective effect of excess potassium in diets deficient in lysine.

Effect of dietary fats and carbohydrates on digestibility of nitrogen and energy supply, and on growth, body composition and serum cholesterol of rats.

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MARSHALL, M. W., ET AL. (USDA, Human Nutrition Research Div., Washington, D. C.). *J. Nutrition 69*, 371–82 (1959).

Rats fed low-fat diets with cornstarch as carbohydrate gained less than rats fed high-fat diet with sucrose as carbohydrate. Weight gains correlated with apparent digestible energy intake but not necessarily with fat intake. Rats fed sucrose stored a higher percentage of their calorie intake as fat than did those which received cornstarch.

Coronary heart disease and dietary habits.

ANON. *Nutrition Revs. 18*, 9–11 (1960).

The statistical relationship between death ratio from degenerated heart disease and dietary data were studied for men aged 55–59 years for 20 countries. A correlation between arteriosclerotic heart diseases and the eating of satd. fats and animal protein was demonstrated.

Experimental production of vitamin B_{12} deficiency in rats and mice on a maize-groundnut-meal diet.

FATTERPAKER, P., ET AL. (Univ. of Bombay, India). *Brit. J. Nutrition 13*, 439–47 (1959).

Vitamin B_{12} deficiency was produced exptl. in rats and mice by feeding them on a maize-groundnut-meal diet. Comparison of the severity and nature of the deficiency with that caused by addn. of iodinated casein to the same diet was made. It is concluded that vitamin B_{12} deficiency induced by the maize-groundnut-diet is substantially free from other metabolic complications and is, therefore, more suitable for studies concerning the metabolic functions of vitamin B_{12} than the one induced by iodinated casein.

The Norrbotten study.

ANON. *Nutrition Revs. 18*, 6–8 (1960).

The relationship between breast and bottle feeding on growth, ossification, antibody response and serum electrolytes was studied in a group of 402 infants in Northern Sweden. The infants were divided into 4 groups, according to duration of breast feeding. Group 1 was breast fed less than 2 weeks, group 2 from 1–2½ months, group 3 from 3–6 months, and group 4 for 6½ months or longer. Differences were found in wt. gain, height, γ-globulin levels and serum Ca concn. No differences were found in the incidence of fever or communicable disease, response to immunization, or incidence of caries. Most, of the differences were statistically significant only when comparison of extreme groups were made and some of the differences existed only for a limited period in early infancy.

Celiac disease and wheat sensitivity.

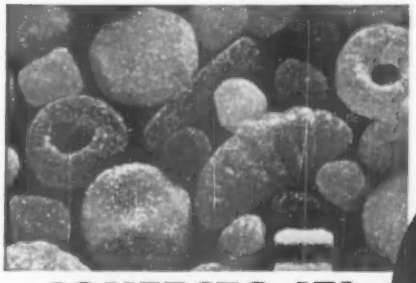
WEIJERS, H. A. AND VAN DE KAMER, J. H. (Central Inst. for Nutrition and Food Research T.N.O., Utrecht). *Pediatrics 25*, 127–34 (1960).

Studies show that sensitivity to wheat in celiac disease is directly caused by the gliadin fraction of wheat gluten which is not properly metabolized due to an "inborn" enzymatic defect in the intestinal wall cells.

The laxative effect of dietary roughage.

ANON. *Nutrition Revs. 18*, 15–16 (1960).

The mechanisms of laxative effect of brans were studied in the pig. Feeding wheat bran increased the water content of the feces. Feeding powdered cellulose had no such effect, but feeding fibrous cellulose reproduced the effect obtained with bran. In vitro tests demonstrated that the fibrous cellulose absorbed and retained much more than the powdered cellulose. The conclusion drawn is that the physical condition or structure of the cellulose and other relatively digestible



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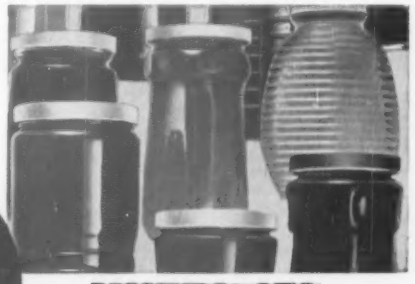

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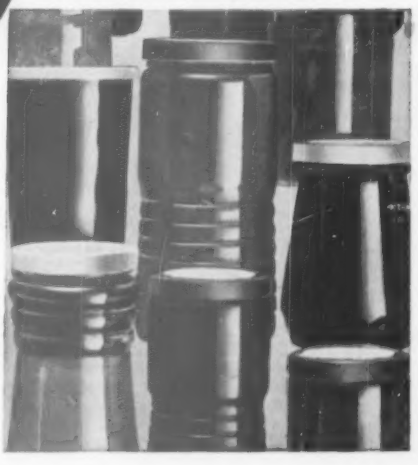

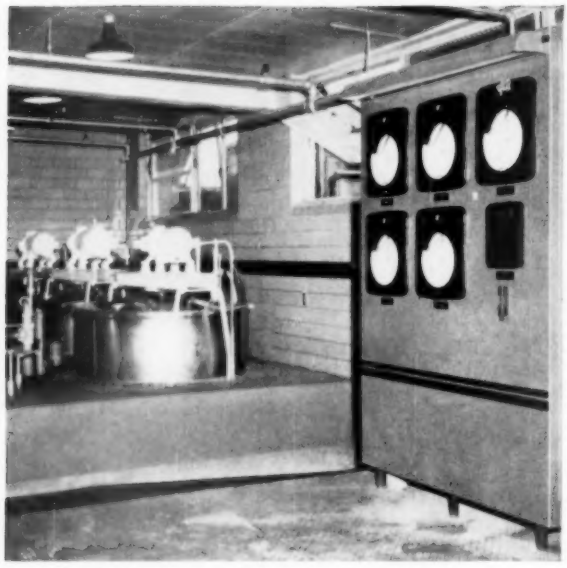

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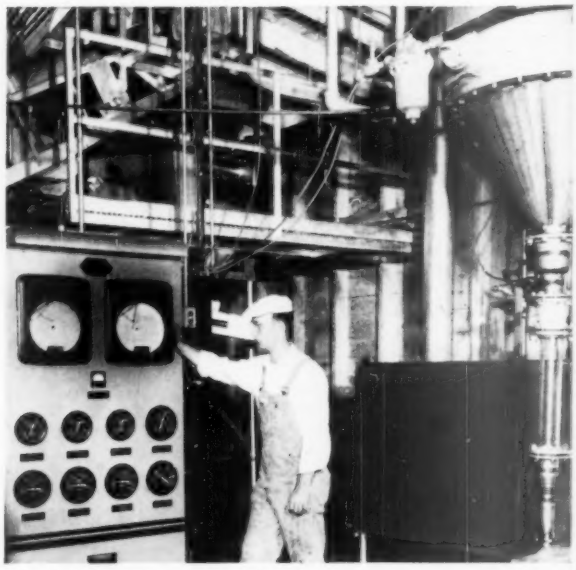

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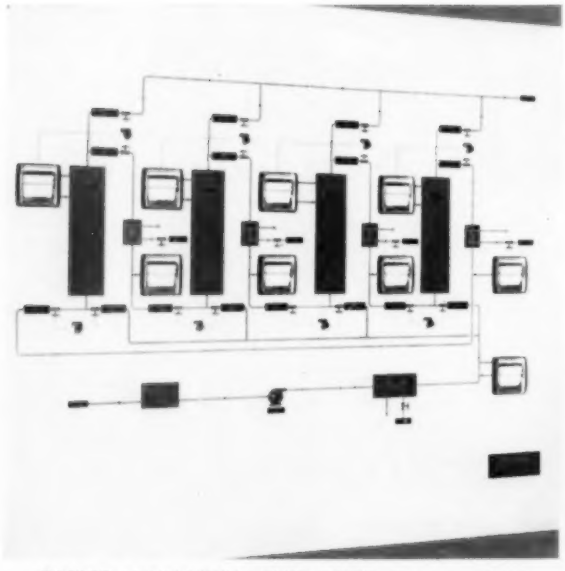

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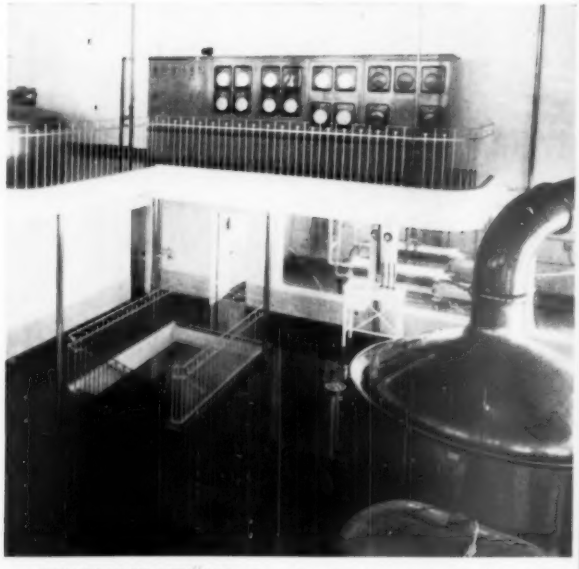

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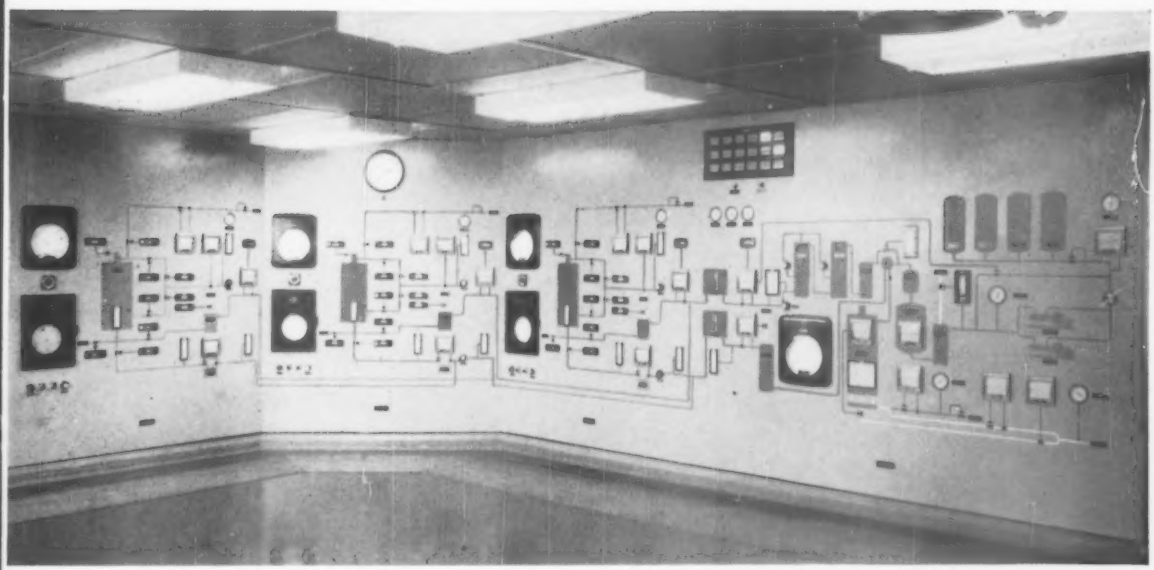

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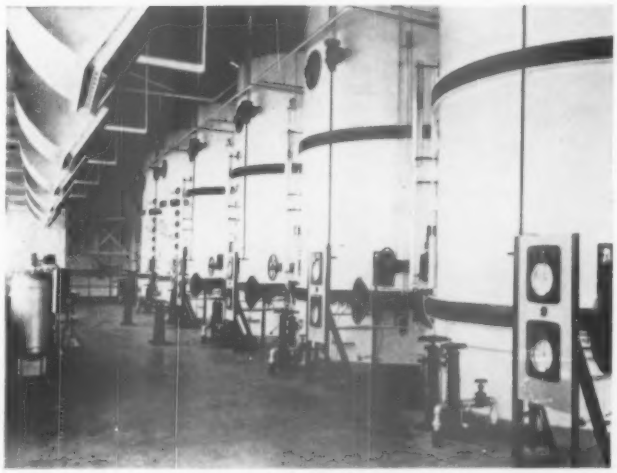

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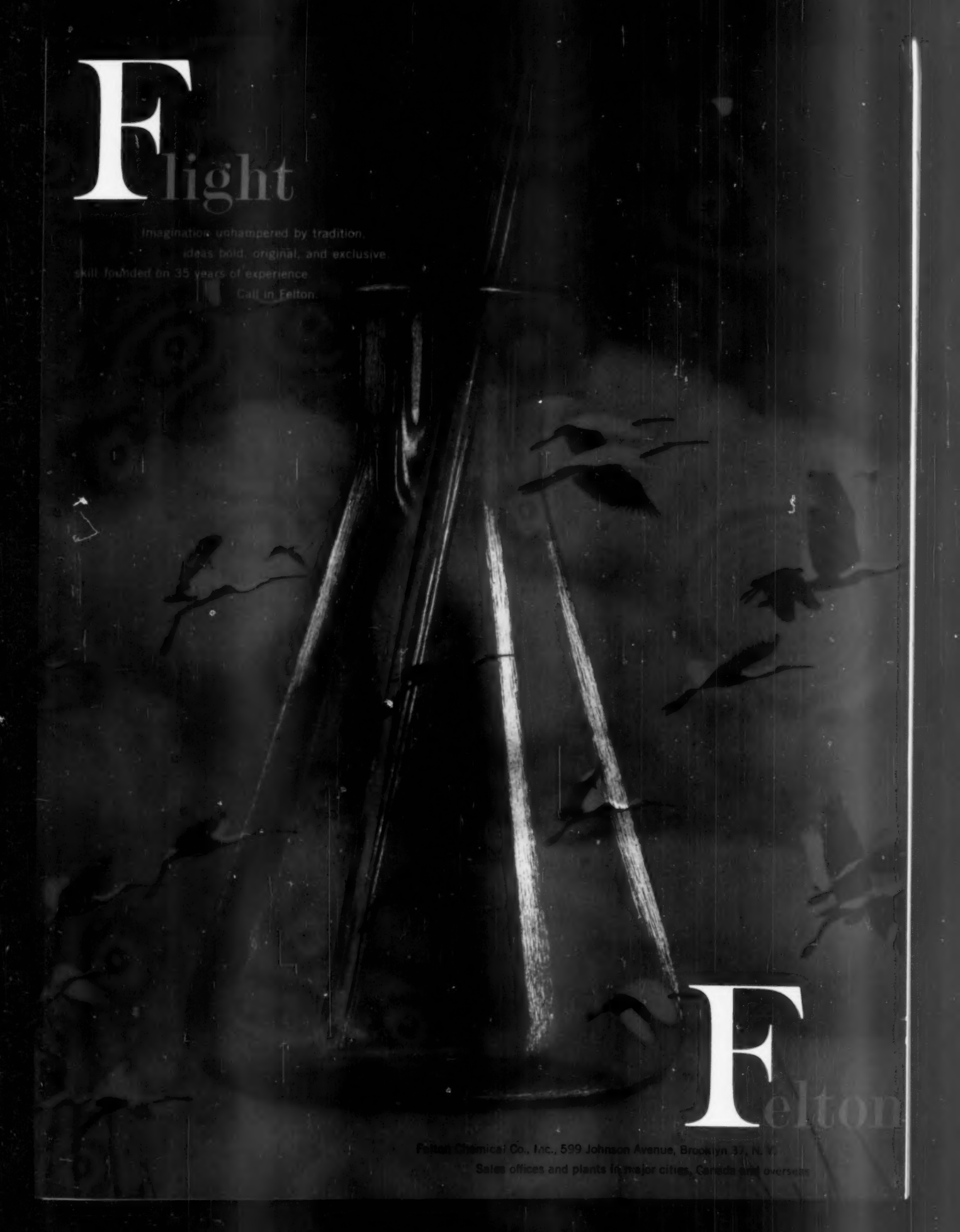
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polysaccharides in bran are responsible for the laxative effect because of the power to retain water.

Toxicology

Effect of normal and high intake of orthophosphate and metaphosphate in rats.

DYMSZA, H. A., REUSSNER, G. AND THIESSEN, R. (General Foods Corp., Tarrytown, N. Y.). *J. Nutrition 69*, 419–28 (1959).

Normal and high levels of phosphorus (0.4 and 1.2% phosphorus) in the form of orthophosphate and metaphosphate were fed to growing rats for 150 days. While the high-metaphosphate diet produced the poorest growth and food and protein efficiency, neither the types nor the levels of phosphates impaired growth conclusively as measured by wt. gained and femur length. All of the data obtained from this study indicated that there was probably adequate absorption and utilization of Ca, P and Fe with both high and normal levels of either orthophosphate or metaphosphate.

Recent studies of organic phosphate poisoning.

WILLS, J. H. (Army Chem. Center, Md.). *Federation Proc. 18*, 1020–5 (1959).

Oximes, such as DAM, 2-PAM and TMB-4, are effective adjuncts to atropine in the treatment of poisoning by anticholinesterase compds., whether of the alkyl-phosphate or the quaternary amine type. These oximes seem to be particularly active in restoring neuromuscular transmission, presumably by reactivation of inhibited cholinesterase at the neuromuscular junction. The oximes, therefore, afford to the clinician a means for controlling the nicotinic phenomena of the cholinergic crisis in myasthenic patients under treatment with anti-cholinesterase drugs and in patients poisoned accidentally or purposely with the same type of compd.

Pharmacologic effects of fractions of oxidized oleate and linoleate.

KAUNITZ, H., ET AL. (Columbia Univ., New York, N. Y.). *Metabolism: Clin. and Exptl. 9*, 59–66 (1960).

Fractions of oxidized oleate and linoleate were fed at a level of 8% in a purified diet to weanling male rats for 3 wks. Some of the fractions exerted characteristic effects on growth, diuresis, organ wts. and cholesterol metabolism. The urea-adduct-forming fraction of the oleate distillate, which consisted of mono- and di-basic, satd., short chain esters, was atoxic and yet, in comparison to lard, produced marked diuresis and reduced liver and serum cholesterol levels.

DETERGENTS

Some factors in the measurement of the suspending power of aqueous detergent/fabric systems.

WEATHERBURN, A. S. AND BOYLEY, C. H. *J. Am. Oil Chemists' Soc. 37*, 20–7 (1960).

The variability assocd. with the usual methods for measuring the suspending power of aq. detergent solns. used to remove soil from textile fibers is pointed out, and a modified method, using multiple washes with very low concn. of soil, is proposed. Two commonly used artificial soils are compared. Micronex, a typical fine particle carbon black, appears to give data in reasonable accord with practical experience while Aquadag, a suspension of graphite particles, tends to magnify some effects and therefore is more useful for specific tests. The influence of hard water and of other inorg. salts on suspending power data is discussed. The need for careful selection of type of soil and fabric and for careful interpretation of data is stressed.

ENGINEERING RESEARCH

The problem of painting rusty steel.

MAYNE, J. E. O. (Univ. of Cambridge). *J. Appl. Chem. 9*, 673–80 (1959).

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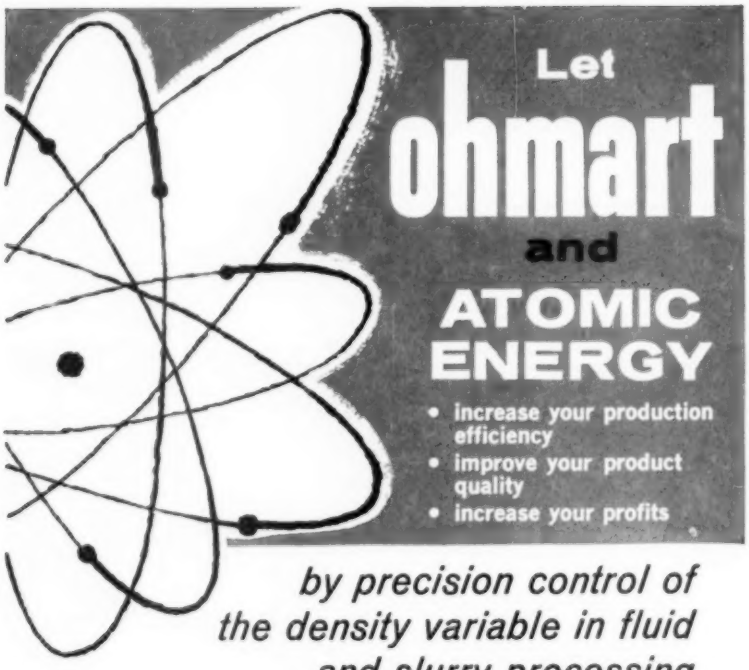

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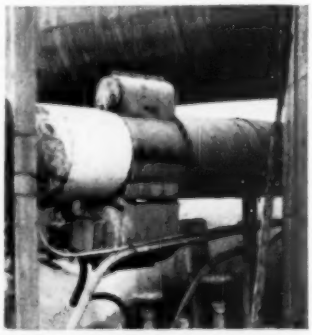

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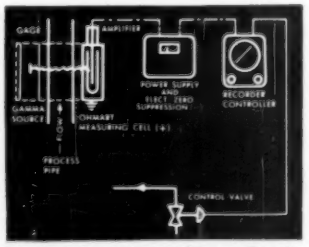

Diagram shows typical Ohmart Density Control System where control of liquid density is by actuation of a valve.

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Engineering representatives in principal areas

Evidence is presented to show that the impermanence of paint over rusty steel is caused primarily by a coating of ferrous sulfate under the mat on the steel surface. Pretreatment of the rusted surface should be directed toward removing all of the ferrous sulfate.

Improve heat transfer coefficients with silicons resin coating.

KULLBERG, G. K. AND KENDALL, H. B. *Chem. Eng. Progr. 56*, 82–4 (Jan. 1960).

Silicon resin coatings improve heat transfer across condenser tubes by promoting dropwise condensation.

FOOD AND FOOD TECHNOLOGY

Cereals and Grains

Improved processing methods for fractionation of wheat flour and the manufacture of vital guten.

ANDERSON, R. A., ET AL. *Am. Miller and Processor 87*, 18–21 (Dec. 1959).

A gluten of 80% protein content and 80% purity is obtained in the continuous batter process for fractionating wheat flour developed at Northern Regional Research Lab. The flour-water batter is withdrawn from the mixer to a pump where water is added to separate starch and gluten. The gluten is then removed on a gyrating screen, washed and rescreened. A process for drying vital gluten by atmospheric drum drying of wet gluten dispersed in dil. acid is also described. 14 references.

Coffee and Tea

Human studies of biologic availability of niacin in coffee.

GOLDSMITH, G. A., ET AL. (Tulane Univ., New Orleans, La.). *Proc. Soc. Exptl. Biol. Med. 102*, 579–80 (1959).

Coffee contains a significant amt. of niacin which is biologically available for man. This beverage can furnish an appreciable share of daily requirement of niacin and should be considered in estimating the niacin content of the human diet.

Eggs

Method of improving the nutritive content of edible avian eggs and end product thereof.

SELTZER, W. Assignor to Vineland Poultry Labs. U. S. 2,915,400. Dec. 1, 1959.

Process for improving the natural nutrient content of edible avian eggs in the shell by wetting the egg shell with an inert liquid carrier and an edible enhancing substance. These substances are caused to enter the interior of the egg through the shell pores and membrane without rupturing the membrane or injuring the egg magma.

Fats and Oils

A highly nutritional margarine.

MELNICK, D. AND GOODING, C. M. Assignors to Corn Products Co. U. S. 2,921,855. Jan. 19, 1960.

The margarine is composed of a milk phase and 80% of a glyceridic fat which contains about 15 to 60% of an essential fatty acid, 10% of a trans fatty acid, an SCI at 70° F. of 4 to 15; and an SCI at 50° of about 2 to 8 times that at 92°. The fatty acid radicals are in random distribution.

Permeability of some fat products to moisture.

LANDMANN, W., LOVEGREN, N. V. AND FUEGE, R. O. (Southern Regional Research Lab., New Orleans, La.). *J. Am. Oil Chemists' Soc. 37*, 1–4 (1960).

The permeability to water vapor, as influenced by temp. and vapor pressure, was measured for cocoa butter, completely hydrogenated cottonseed oil, mixts. of completely hydrogenated cottonseed oil and cottonseed oil, paraffin, chocolate liquor, and sweet milk chocolate in order to obtain information useful in developing improved confectionery fats. The permeability const. was calcd. in terms of grams of water diffusing through a centimeter cube in one second under a vapor pressure gradient of one mm. of Hg across the cube. Under the test conditions employed, the permeability const. for cocoa butter at room temp. was found to vary from 5.8×10^{-12} to 81.6×10^{-12}. The permeability consts. for the highly hydrogenated cottonseed oil and the cocoa butter, under comparable conditions at room temp., was found to be approx. 1.3×10^{-12} and 33×10^{-12}, resp.

Feedstuffs

Utilization of diets containing oats and oat husks ground to different degrees of fineness.

CALDER, A. F., ET AL. (Rowett Research Inst., Aberdeen, Scotland). *J. Sci. Food Agr. 10*, 682–91 (1959).

Oats ground to 3 defined degrees of fineness were used in fattening pig diets as the sole cereal source. Growth and digestibility trials showed that there was no advantage to be gained in grinding finer than is attainable by ordinary farm grinding equipment. When oats were very finely ground there was a small reduction in the apparent digestibility of the protein of the diet and in the retention of N. Digestibility trials with oat husks ground to 3 defined degrees of fineness and included in conventional barley-groundnut meal fattening diets shows that there was no material effect of the fineness of grist on the digestibility of org. proximate constituents.

Milk

Synthetic milk.

OTTO, H. L. U. S. 2,923,628. Feb. 2, 1960.

Provides for the compn. of a synthetic unsatd. fatty acid milk which comprises approximately 60% to 80% water, 5% to 10% whey protein, 5% to 10% fat, 5% to 10% lactose and 5% to 10% salts. The fat is in the form of fatty acids contg. 48% to 53% of linoleic acid.

INDUSTRY NEWS

Corn Industries Research Foundation, Inc., recently announced publication of the second edition of *Corn Oil*, a 20-page booklet illustrated with photos and charts. The booklet is obtainable free, on request to Corn Industries Research Foundation, Inc., at 1001 Connecticut Ave., N. W., Washington 6, D. C.

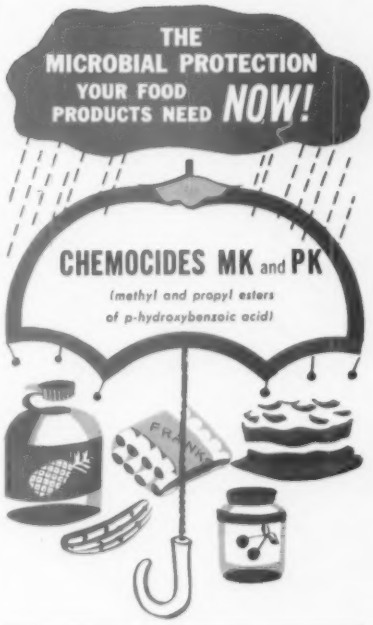
A new illustrated catalog of Lambda-Pettes®, the micropipettes manufactured by Research Specialties Co., is available on request from Research Specialties Co., 200 South Garrard Blvd., Richmond, Calif.

James Dole Engineering Company recently released its new brochure "The Dole System of Aseptic Canning." It is available upon request to James Dole Engineering Co., Russ Building, San Francisco 4, California.

A new bulletin available from The Pfaudler Co. describes the RP-210 Ten Station Piston Filler. For further information write The Pfaudler Co., 1113 West Avenue, Rochester, New York.

Canadian Institute of Food Technology will hold its third annual conference June 9 and 10 at the Royal Alexandra Hotel, Winnipeg, Manitoba. Theme of the meeting will be Food Quality. Further details are available from A. G. McLeod, Manitoba Department of Health, 320 Sherbrook Street, Winnipeg 2, Manitoba, Canada.

Second International Course on Lyophilization. For a two-week period starting August 29, Lyon, France, will be the scene of a



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unique course in freeze-drying for those who are using this technique: research workers in the biological and botanical sciences, and those engaged in clinical and experimental surgery. Courses will be presented in French and English by a distinguished faculty, including Dr. A. S. Parkes of the National Institute of Medical Research, London, and Professor R. I. N. Greaves of Cambridge University, Dr. H. T. Meryman of the Naval Medical Research Institute, Bethesda, Maryland, and others equally recognized in their own specialized fields.

The course of lectures will cover every phase of freezing and drying, theory, applications to the preservation of biological products, foodstuffs, possibilities for the preservation of whole organisms, and projected future trends.

Participants will have the opportunity of practical exercises with a great variety of apparatus. There will also be much supplementary material in the form of exhibits of technical apparatus, movies and lectures on related topics. An attractive feature of the course will be the opportunities for informal discussions afforded by the fact that participants, both faculty and students, will be quartered in the buildings where the main part of the instruction will be carried on.

Full details concerning the Second International Course of Lyophilization, including costs, living accommodations, registration, etc., may be obtained by writing directly to: Dr. Louis R. Rey, Directeur des Cours Internationaux de Lyophilization, Laboratoire de Physiologie, Ecole Normale Superieure, 24, rue Lhomond, Paris 5e, France.

EXPANSION NEWS

Opening of a new Atlanta plant of the Canco Division of the American Can Company took place Thursday, March 10, 1960. The modern one-story plant, designed and engineered by the American Can Company and built by Beers Construction Co., occupies approximately 150,000 square feet of floor space. Four production lines are in operation and a single line may produce metal containers at speeds up to 500 a minute. In addition to metal cans, metal and paper containers will be produced for biscuit dough.

In January 1960, Norda Essential Oil and Chemical Company has voluntarily made plant improvements totalling $283,000. The Norda plant in Hanover, New Jersey, has been modernized by the replacement of several old buildings, as well as by re-painting, repairing, general improvement, and addition of new machinery and storage tanks. The amount was reported to be the largest single expenditure for plant improvement of this type in the food field during the month of January, according to the Food and Drug Administration.

A four million dollar food research building and pilot plant was dedicated May 5 and 6 at Cornell University's New York State Agricultural Experiment Station at Geneva, N. Y. The most modern structure of its kind in the United States, it will provide outstanding research facilities for the promotion of the agriculture of New York State. The formal dedication ceremony took place Thursday afternoon, May 5th. Assistant Secretary of Agriculture Ervin L. Petersen spoke on "The Significance of Agricultural Research in the Development of an Improved Food Supply." A dedication banquet on the evening of May 5th was addressed by J. George Harrar, Director for Agriculture for the Rockefeller Foundation, who spoke on "Food in National and International Welfare." A dedication symposium on "Food and Health" was held on May 6th. Featured speakers were William J. Darby, Director of the Institute of Nutrition, Vanderbilt University, whose topic was "What is an Ade-

quate Diet for Young and Old"; Emil M. Mrak, Chancellor of the University of California at Davis, who discussed "The Role of Chemistry and Technology in the Development of Modern Foods"; Philip L. White, Executive Secretary of the Council on Foods and Nutrition of the American Medical Association, who spoke on "Public Education and Food Attitudes"; and John B. Youmans, Technical Director of Research, U. S. Army Medical Research and Development Command, who described "What Lies Ahead in Nutrition."

PERSONNEL

Mr. Charles C. Bryan, president of Firmenich, Inc., announced the appointment of **C. Richard Myers** as branch manager of the Chicago Sales Office of Firmenich & Company. Mr. Myers is a 1943 graduate of Purdue University with a B.S. in biochemistry. During the war, Lt. Myers was a pilot in the Naval Air Corps. He then joined American Foods, Burnett Extracts and Clapp Baby Foods Divisions. Prior to joining Firmenich as assistant branch manager of the Chicago office, he was technical sales representative for Sterwin Chemicals.

In announcing several executive promotions, Basic Food Materials, Inc., of Vermillion, Ohio, recently named IFT Member **Harold Markman** to the position of Vice President in charge of Research and Production.

A meeting of Wisconsin Governor Gaylord Nelson's special committee to survey the use of chemicals in agriculture was held in Madison, Wisconsin recently. The special committee, the first statewide group of its kind in the nation, was created by Governor Nelson to develop a decisive and consistent public policy in respect to regulating the use of chemicals as feed supplements, food additives, pesticides, and growth regulators. Three of the eleven members of the special committee include IFT Members **Dr. Conrad A. Elvehjem,** President of the University of Wisconsin, Chairman; **Dr. Henry T. Scott,** Director of Biological Laboratories of the Wisconsin Alumni Research Foundation; and **Dr. Aaron Ihde,** Professor of Chemistry and member of the Wisconsin Food Standards Advisory Committee.

The University of California and the state's food industry paid tribute to **Dr. William V. Cruess,** pioneer food scientist, in ceremonies naming the food technology building on the Davis campus in his honor Saturday, March 19. Action of the University Regents last month designated the building as Cruess Hall.

The ceremonies and an open house were held in conection with the annual Olive Day program at Davis. Cruess, now retired after 40 years of service to the University as a teacher and researcher, is internationally famed for his contributions to the food processing industry. In 1916, he organized the University's curriculum in food technology at Berkeley, one of the first such programs in the nation.

Professor Cruess also originated the University's research program in the canning, drying, fermentation, and freezing of fruits and vegetables. He has published more than 400 scientific papers, bulletins and circulars on food science. His textbook, *Commercial Fruit and Vegetable Products*, is used in colleges throughout the world. Technical contributions by Cruess are credited with a dominant role in the development and growth of California's large and successful wine, olive, and canned, dried, and frozen food industries.

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The newly founded **Rohland A. Isker Award** for outstanding contributions to military food and packaging progress, was presented on April 21, to joint winners by the Research and Development Associates, Food and Container Institute, Inc. at their 14th annual meeting at the Congress Hotel.

R. A. Isker

One award was presented to **Joseph P. Akrep,** container technologist at the Quartermaster Food and Container Institute for the Armed Forces, Chicago, for development of a jeep-type, fork-lift vehicle for handling unit loads of military supplies. Mr. Akrep holds a B.S. and an M.S. degree (mechanical engineering) from Stevens Institute of Technology, Hoboken, N. J. The second award was presented to three former members of the QM Food and Container Institute staff for the development of an instant bread mix utilizing chemical leaveners. They are **Dr. Samuel A. Matz,** who obtained his doctorate at the University of California, Davis, and is presently head, refrigerated dough laboratory, Borden Research Cen-

tre, Syracuse, N. Y. **Charles S. McWilliams** (Pennsylvania State University) is bakery production instructor, American Institute of Baking, Chicago, and **Jason Miller** (Boston University) is a bakery chemist, E. F. Drew and Co., Inc., Boonton, N. J.

A non-profit organization maintaining liaison on food and container research and development between the military and industry, the Associates is composed of leaders in the sciences and technology related to food and packaging. Commandant of the Subsistence Research and Development Laboratory (SRDL), predecessor organization of the Food and Container Institute, Col. Isker directed the work of the SRDL immediately prior to World War II as well as throughout that conflict. He and his staff had much to do with the design and development of operational rations and the packaging used in World War II. The Institute has a world-wide reputation and military and civilian missions from more than forty nations have visited the Chicago organization to study its procedures and work.

Dr. John H. Litchfield has joined the staff of Battelle Memorial Institute and will head up research studies in food technology and fermentation within the Biosciences Division. He comes to the Columbus, Ohio, research center from Illinois Institute of Technology, where he was assistant professor of food engineering. On the campus and in industry, Dr. Litchfield has directed studies on the use of microorganisms as potential food sources, nutritional evaluation of food processes, and use of radiation—particularly non-ionizing radiation—to preserve foods. His work has resulted in a number of papers on food processing and microbiology. Before joining the Illinois Tech faculty, he served as research food technologist for Swift and Company, food advisor for the U. S. Army Quartermaster Corps, and chief chemist for Searle Food Corporation.

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Dr. Roy E. Morse, formerly Chairman of the Food Science Department at Rutgers University, and **Mr. Edward Seltzer,** Chief Research Engineer of Thomas J. Lipton, Inc. for the past several years, have been named Assistant Directors of Research, it was reported recently by W. Gardner Barker, Lipton President.

Robert E. Feeney (Ph.D., Wisconsin, 1942), nationally known for his research in protein chemistry, joined the University of California staff at Davis on March 15, 1960, as a professor of food science and technology. He was formerly with the University of Nebraska, where since 1953 he has headed the Department of Biochemistry and Nutrition. Feeney will teach courses in the biochemistry of food proteins and do basic research work emphasizing the proteins of milk, eggs, and meat, said Dr. George F. Stewart, chairman of the Department of Food Science and Technology at Davis. "He fills a strategic need of the department because of the importance of proteins in foods and nutrition," Stewart declared. Dr. Feeney will be a member of a team of biochemists drawn from the several departments that conduct basic research in protein chemistry at the University of California. With the addition of Feeney, as the first full-time man in his field, the food science and technology department at Davis looks forward to adding research projects on the application of protein chemistry to the processing, manufacture, storage, and distribution of foods, including the effects of freezing, concentrating and drying, and heat processing.

R. E. Feeney

After World War II, in which he served as a food and nutrition officer, he returned to California in 1946 as a biochemist in the U.S.D.A. Western Regional Research Laboratory at Albany. From there he went to the University of Nebraska faculty in 1953.

Feeney is the author or co-author of more than 40 scientific papers, and he is the co-holder of three patents. He has been active in the American Chemical Society and the National Science Foundation, and he has received several research grants from the National Institutes of Health.

In 1958, he spent the summer in California as a fellow of the San Diego Zoological Society.

IN MEMORIAM

Dr. Carl R. Fellers, 66, of Amherst, Massachusetts died suddenly on February 22nd at St. Ann's de la Pocatiere, Quebec, where he was delivering special lectures at the School of Fisheries. Dr. Fellers was an internationally known, renowned food technologist. He was born at Hastings, New York on October 4, 1893. He received an A.B. degree from Cornell University in 1915 and the M.S. degree in 1916 and Ph.D. degree in 1918 from Rutgers University.

C. R. Fellers

From 1918 to 1919, he was associated with the U. S. Public Health Service and for this service was awarded a certificate of merit from the Surgeon General. In 1920 he served as bacteriologist with the U. S. Department of Agriculture Bureau of Chemistry and Soils at Washington, D. C. From 1921 to 1923 he was a research bacteriologist with the National Canners Association at Seattle, Washington. During 1924 and 1925 he was associate professor of food preservation, fish and marine products at the University of

Washington, Seattle. In 1926 he joined the staff at the University of Massachusetts as research professor of food technology and served as head of the department from 1941 to 1957, when he retired.

During World War II, Dr. Fellers was post chemical officer at Fort Devens and served as Lieutenant Colonel, QMC, in the Southwest Pacific Theatre, where he acted as liaison officer with the Australian Government. In recognition of this service he was awarded the bronze star.

Dr. Fellers was an inventor of methods for the pasteurization of dried fruits and the canning of Atlantic crab meat. He was one of the founders of the Institute of Food Technologists of which he was president in 1949. He was also a recipient of the Babcock Award of the Institute of Food Technologists. He was a member of many other research, scientific and honorary societies including the American Public Health Association, American Chemical Society, Society of American Bacteriologists, American Fisheries Society, the New York Academy of Science, the American Association for the Advancement of Science, Sigma Xi, Phi Kappa Phi and Phi Tau Sigma. He was the author of many scientific and technical articles on bacteriology, chemistry, and food technology.

Dr. Fellers is survived by his wife, the former Miss Josephine Sanders; five sons, Dr. Francis X. Fellers of Cambridge, Massachusetts; John C. of Bridgeton, New Jersey; Paul J. of East Lansing, Michigan; David A. of New Brunswick, New Jersey; Stephen G. at home; three daughters, Mrs. Anthony Lopez of Blacksburg, Virginia; Mrs. Warren Averill of Amherst, Massachusetts and Mrs. Donald Goodyear of Sunderland, Massachusetts; three brothers, George and Roy Fellers of Mexico, New York and Alvah Fellers of Syracuse, New York; and eight grandchildren.

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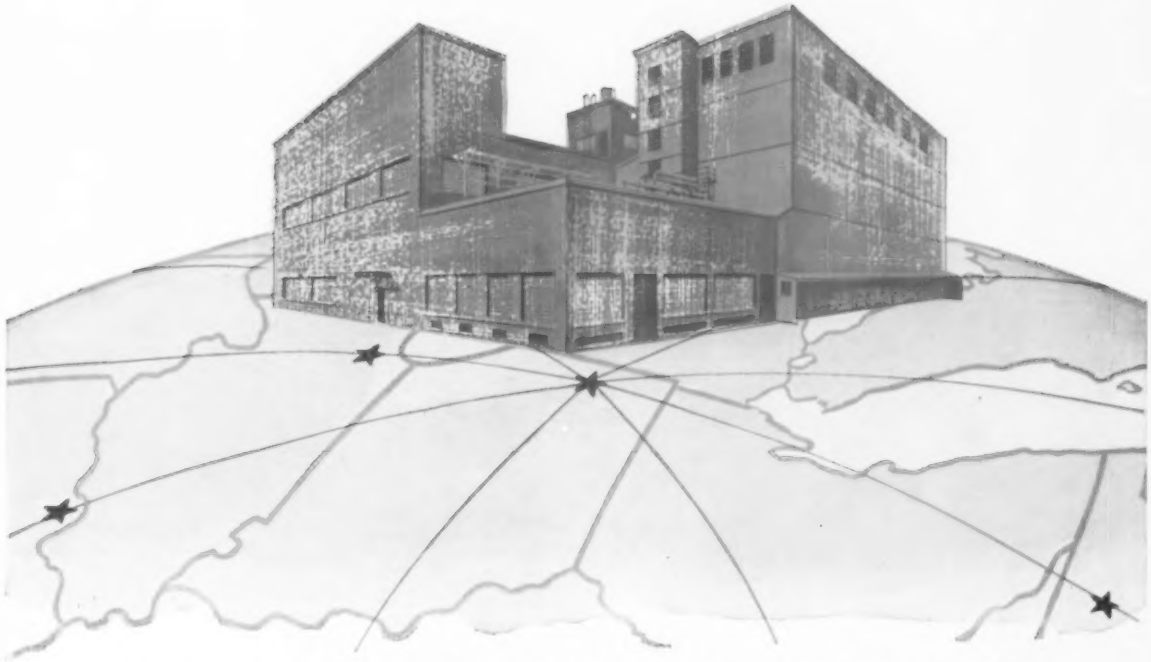

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